MONITORING WATER-WASTEWATER TREATMENT OPERATIONS

DRAFT MANUAL

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MOE

Ontario

Ministry of the Environment

The Honourable
George R. McCague,
Minister

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Deputy Minister

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SECTION I Procedures for Plant Evaluation

The evaluation of a wastewater treatment plant consists of an in-depth analysis of the following basic elements:

Plant performance
Operational problems
Sampling and testing program
Laboratory facilities
Maintenance data program

Information and data for each element are gathered and analyzed in four interrelated phases, namely

1. Preparation for site visit
2. On-site inspection
3. Problem identification
4. Total plant evaluation (including Documentation)

The estimated evaluation time will depend on the size and complexity of the plant, the amount of preparation on the part of the investigator, and the willingness of the plant personnel to cooperate with the investigator.

For planning purposes, the following table gives values which can be used for the initial evaluation. The estimate of the times required to perform a treatment plant evaluation will vary with the complexity of the treatment facility and other factors; this variation could be as great as 50 percent.

TREATMENT PLANT EVALUATION PERIOD
(days)

	Plant Size (MGD)		
	1	10	100
Preliminary preparation	¼	1	1½ to 2½
On-site investigation			
Visual Inspection	¼	½	1 to 1½
Record Analysis	1	2½	2½ to 4
Problem Evaluation and Solution	1	0 to 3	0 to 4
Written Report	½	1	1
Total Days (maximum)	3	8	13

I PREPARATION FOR SITE VISIT

Preparation for the on-site inspection should include compilation and review of information which provides a description of the plant's physical setting, plant design details, plant operating personnel, and any available performance records, previous inspection reports, compliance orders, etc. Reference material relevant to the type of plant being evaluated should also be reviewed (see Section II and the Appendixes).

The following are specific steps suggested for use in preparation for the on-site visit:

1. Compile and Review Information on the plant

Information describing the physical location of the plant will be required in the evaluation. The information should include the following:

(a) Classification of Treatment System

Type of plant (see Appendix A)
Contributory population (domestic, industrial, etc.)
Wastewater system (sanitary, combined, etc.)
Determine, if possible, the characteristics of the plant's influent and effluent. This should include values of the parameters measured by the plant (BOD_5, pH, COD, temperature, etc.), flow quantity and variations with time.

2. Compile and Review Information Describing the Plant and Staff

This should be accomplished in advance of the plant visit. The information required to make this comparison includes:

Size of plant (design, average daily flows, peak flows)
Type of unit operations
Historical operating data
Review all relevant plant documents such as design drawings, operating manuals for various pieces of major equipment, and summary (or monthly) operating reports.

This information may be compared with sections of the manual or other sources which give information on the following:

Wastewater treatment systems operational data (see Section II of this manual)

3. Prepare a Pre-Visit Evaluation Data Sheet

Data will be needed prior to the evaluation to insure adequate data-gathering at the time of the on-site visit. The pre-visit evaluation guide should include a summary of all background information.

Pre-Visit Evaluation Guide

	CHECK WHEN INFO OBTAINED
Plant Identification (Name, Owner, etc.)	
Plant Location	
Operator in Charge	
Date of Evaluation	
Evaluation by	
Date of Plant Construction	
Name of Design Firm	
Background Information (obtain prior to visit)	
1. Type of Plant	
2. Schematic of Flow Route to Units on Line	
3. Contributory Population	
Domestic	
Industrial (P.E.)	
Other	
4. Type of Wastewater System	
Combined	
Sanitary	
Industrial	
5. Geographical Climatic Effects	
Temperature Ranges (degrees F) _____ to _____	
Rainfall Extremes (inches) _____ to _____	
6. Sewer System Sewage Bypassing	
Location of possible sewer bypassing	
Location of all pumping station bypassing	
Frequency of Bypassing	

7. Plant Wastewater Characteristics (Based on previous year's data).

	FLOW					NITROGEN	
	Peak Day (mgd)	Avg Day (mgd)	BOD mg/l	SS mg/l	Total P mg/l	Ammonia	Total K
a. Plant influent							
b. Plant effluent							
c. Overall performance (%)							
d. Design and/or manual recommended performance values (%)							
e. Existing receiving water quality							
f. Required receiving water quality							

8. Possible Problems
   a. Identified from operating reports
   b. Identified from previous inspection reports
   c. Complaints

II ON SITE-INSPECTION

The inspection of the plant should be accomplished in several phases with each phase being progressively more detailed. Use of the On-site EVALUATION GUIDE will facilitate the recording of pertinent information during the inspection. The visit(s) would typically consist of two stages:

Stage One--familiarization with plant staff, a general orientation and overview of the plant and its operation, meet initially with the chief operator. Have him describe the plant and its prinicpal operating characteristics, on a schematic basis (this and the following steps are to help orient you to the plant, but also to give you an

indication of how well the staff understand the system).

Determine routine plant performance and compare this with predicted design performance (see norms section of the manual).

Stage Two--problem identification with an evaluation as to effect on overall plant performance. This phase also includes the procedure for laboratory evaluation.

Problem identification begins with a tour of the facility. Have the plant operator give you a complete tour of the facilities. In a waste water treatment plant watch for and inquire about:

-Excessive particles and/or floc flowing over overflow weirs

-Excessive grease and scum build-up

-Any unusual equipment such as special pumps, chemical feeders, temporary construction on structures or other jury-rigged systems which are being used to correct problems (or possibly causing them)

-Evidence of flow in bypass channel to parallel units because problems have come up in normal operating units

-Excessive odors

-Abnormal color of wastewater in various process stages.

If any special plant modifications were made, determine:

-Purpose

-Physical makeup

-Effect on the other treatment processess by comparing old operational data with data after modification

-If they were approved.

REVIEW RECORDS

In general, all plant operating records should be analyzed and compared with the information in the manual and/or other sources for consistency, method of calculation and to verify that recorded values are within the recommended ranges. The following records should be reviewed:

FLOW Hydraulic data are reviewed for:

Consistency with the design flow and with present population served

-Over-and under-loading of the various treatment units.

-Meter calibration (personal check if possible, see supporting information).

UNIT OPERATIONAL DATA (BOD, COD, SS, etc.) are reviewed for:

-Consistency with design specification and values indicated in the manual or other sources

-Extreme values for the daily flows.

MAINTENANCE DATA The maintenance program is usually a good indicator of operational quality; this can be indicated by checking:

-Type of routine being used for maintenance scheduling.

III PROCEDURES FOR PROBLEM EVALUATION

In general, the problems detailed in the manual are those most commonly encountered. However, these procedures can be used for any type of problem evaluation. The first step in problem evaluation is to determine if the plant is meeting design performance standards by comparing its effluent quality and overall removal efficiencies with those specified by the design. If the plant does not routinely meet performance specifications, it will be necessary to determine whether the deficiency is due to problems which fall into two categories:

PROBLEM DEFINED--If the treatment plant operator has defined the problem:

a. Verify general area of problems, such as related to process, maintenance or design, sampling, etc.

b. For common process problems, refer to that section of the manual dealing with the problem (see Section IV).

c. Develop sampling and testing program to provide additional data, if needed (see Section III).

PROBLEM UNSPECIFIED--If effluent discharge does not meet required standards and no definite problem area has been established:

a. Review flow and process records again in greater detail.

b. Recheck sampling and testing procedures required (see Section III).

c. Compare sampling and testing program against recommended programs in the manual.

d. Recommend a modified testing and sampling program to furnish additional data for evaluation (see Section III).

e. Compare the data with the problem indicators detailed in the manual (see Section IV) to see if there is a solution offered.

f. MOE may have experts on staff who should be consulted before an outside expert is engaged.

MAINTENANCE PROBLEM--Refer to sample maintenance program and compare with actual plant program; recommend new program where needed.

On-Site Evaluation Checklist

(Sewage Treatment Plant)

1. Flow

   Design (actual) _____

   Daily Average _____

   Peak _____

From plant flow records note any seasonal variation or erratic flow patterns.

2. Process Units Employed and All Pertinent Information

	Operational Parameters		Loading Rates	
Unit Process	Existing Plant Values	Design and/or Recommended Manual Values	Existing Plant Values	Design and/or Recommended Manual Values

3. Historical Operational Data

   Organize data to see if following apply:

   1) Equipment failure - when, what type failure, how long out of service

   2) Extreme weather conditions

   3) Excessive loadings on plant:
   -Flow--wher, how long, results of
   -Organic - when, how long, results of

   4) Changes in process operation, such as:
   -Increasing air flow to activated sludge units
   -Decreases in detention times
   -What caused changes? Are changes still in effect? Why?

4. Laboratory Evaluation

Type of Tests Performed for Treatment System Evaluated			Testing Procedures and Equipment Used	Type of Tests Performed for Treatment System as per Manual
Type	Frequency	Location		

IV TOTAL PLANT EVALUATION

This should include the following:

1. TOTAL EVALUATION OF PLANT--utilizing the Checklist Data

   a. Modification of initial evaluation, if appropriate
   b. Differences in existing plant performance and operational data with design and/or manual operational or performance data
   c. Type of sampling program required to give needed data
   d. Maintenance system needed
   e. Laboratory equipment needed
   f. Problems encountered
      Those corrected by visit
      Those that need outside help to correct
      Proposed solutions.

2. FINAL REPORT--should contain the following elements:

   a. Summary of on-site visit
   b. A list of problems encountered
   c. Solutions recommended
   d. Proposed action.

Guide for Overall Evaluation

		Yes	No
I.	OPERATING PROBLEMS		
	Are there problems affecting the performance of this plant?		
	Can they be solved without major construction?		
	Are the skills to solve the problem available among the staff?		
	Was a solution suggested by the evaluator?		
	Is it a permanent solution?		
II	THE SAMPLING AND TESTING PROGRAM		
	Are the sampling locations suitable?		
	Are testing procedures "Standard methods?"		
	Is testing frequency adequate to maintain process control?		
III	LABORATORY FACILITIES		
	Is the laboratory well-organized and apparently functioning as intended?		
	Is there enough equipment to perform all the necessary tests?		
	Is the equipment being properly used?		
V	OVERALL PLANT PERFORMANCE		
	Is it operating to its design specifications?		
	Is it meeting discharge requirements for its location?		
	Even if adequate, can plant performance be improved by simple and/or inexpensive changes?		

Evaluator: In completing the Guide, if any of the answers are no, the following steps should be taken:

1. Submit a report which includes:

   Summary of on-site visit
   A list of problems encountered
   Solutions recommended
   Proposed action.

2. Discuss the recommendations with treatment plant staff.

3. In cooperation with the plant operator (and local officials, if necessary), decide on a course of action to solve the problem(s).

4. After a suitable period of time, revisit the plant to make a re-evaluation.

Section 2

WASTEWATER TREATMENT OPERATIONAL DATA

This section of the manual contains data on the common operating parameters, loading rates, waste products accumulated from process operation, and the support systems which are used in the various unit operations and processes.

Once the plant has been classified and the type of unit operations and processes have been determined, the information in this section will serve as a guide to evaluation of the overall plant operation. If operating and performance data are largely different, investigation of plant processes should be made to determine if the problem is with equipment or process failure. These should be noted, and if remedial solutions can be determined by use of this manual (Problem-Solution Section IV, this manual), they should be suggested to the plant operator. Inspectors should remember that occasionally treatment plants may produce a high quality effluent in spite of operating parameters which lie outside of these common operating parameters. Where problems are beyond the scope of this manual or experience of the evaluator, the evaluator should assist the operating authority to obtain proper outside help.

In the total evaluation of the plant, a list of the problems encountered should be made and the evaluator must record the steps that are being taken or were suggested to correct them. A return visit should be made after the operating authority has had sufficient time to correct the problems and a new evaluation carried out then.

Section 3

SAMPLING AND TESTING

INTRODUCTION

The sampling and testing program described in this section is designed to determine

the type of sampling to be done
the locations of sampling points
the analyses to be performed for the particular treatment system.

In addition, recommended storage temperatures and durations are given, as well as a list of the laboratory equipment that will be needed to perform the various analyses. Sample forms are included which are intended as aids for the systematic recording of the results of the various analyses.

The information in this section can be used with the problem/solution section of this manual (Section IV) either to establish a sampling and testing program to solve a particular problem involving a particular process, or to institute an adequate sampling program at a plant lacking such a program.

A comparison of the type and frequency of tests needed to control the various processes with the sampling program actually being performed at the plant site can help evaluate the process control system of the plant. In the overall evaluation of the plant, this comparison would be used in ratings of the sampling and testing program, and the laboratory facility to perform necessary tests.

GENERAL

The characterization of waste, whether it be domestic or industrial in origin, begins with sampling. A wastewater treatment plant consists of various components which make up the treatment system. A program of sampling and testing which measures influent, effluent and individual process units on a scheduled basis not only means better plant performance evaluation but can also identify changes quickly so that immediate corrective measures can be taken.

because it provides proof the process is working and safe water is being supplied, and identifies unit process inadequacies so corrective measures can be implemented.

The extent of any testing program should be determined by the size and type of treatment facility and the type and quality of receiving waters.

If analyses are to be carried out on the site, the treatment plant should be provided with adequate laboratory facilities for the performance of tests necessary for the proper operation of the plant.

Some more sophisticated treatment plants are provided with instrumentation which allows for constant monitoring of certain treatment processes and it is customary for this information to be telemetered and recorded at some convenient location within the plant control building. Telemetered information can include, but not be limited to, primary effluent pH, final effluent chlorine residual, aeration tank dissolved oxygen, and sludge density. Even though the instruments performing these monitoring functions can be highly reliable, it is recommended that their performance be checked periodically by analyzing concurrent and identical samples.

THE SAMPLING PROGRAM

A well-organized, effective sampling program must consider several factors:

- -Type and scheduling of sampling needed for the specific analyses to be made
- -Quantity of samples needed
- -The most effective sampling locations
- -Handling and storage procedures (between sampling point and testing site)
- -Types of sample testing to be done.

Tables III-I and III-2 indicate the common constituents which are analyzed from the flows of various waste treatment processes. The matrix (Table III-2) also indicates points in the sewage treatment system where samples should be taken. Tables III-3 and III-4 indicate the common constituants which are analyzed from the flows of various water treatment plant processes. The indicated sampling

frequencies are minimum values and are dependent on or can vary with size of plant and staff, complexity of the system, the nature of the waste handled, and on the effluent requirements placed on the facility.

The test indicated should be performed as frequently as indicated in accordance with the prevailing requirements of the agency governing waste discharge or drinking water quality, within the area in which the plant is located. Every effort should be made to perform the tests in accordance with their scheduled frequency. A test with a "weekly" frequency should be run at a regular hour and day of the week.

Table III-I

PROCESS TESTING GUIDE

PROCESS	TEST	FREQUENCY
	PRETREATMENT	
Grit Removal	Volatile Solids	Daily
	Total Solids	Daily
	Moisture Content	Daily
	PRIMARY TREATMENT	
Primary Sedimentation	Settleable Solids	Daily
	pH	Daily
	Total Sulfides	Daily
	Biochemical Oxygen Demand	Weekly
	Suspended Solids	Weekly
	Chemical Oxygen Demand	Weekly
	Dissolved Oxygen	Weekly
	Grease	Weekly
	SECONDARY TREATMENT	
Activated Sludge	Suspended Solids	Daily
	Dissolved Oxygen	Daily
	Volatile Suspended Solids	Weekly
	Turbidity	Daily
Trickling Filter	Suspended Solids	Daily
	Dissolved Oxygen	Daily
Oxidation Ponds	Dissolved Oxygen	Daily
	Total Sulfides	Daily
	Total Organic Carbon	Weekly
	Total Phosphorus	Weekly
	Settleable Solids	Daily
	pH	Daily
	Total Sulfides	Daily
Final Sedimentation	Biochemical Oxygen Demand	Weekly
	Suspended Solids	Weekly
	Chemical Oxygen Demand	Weekly
	Dissolved Oxygen	Weekly
	Turbidity	Daily
	MBAS	Weekly
Chlorination	DISINFECTION	
	Chlorine Residual	Daily
	MPN Coliform	Weekly
Thickening	SOLIDS HANDLING	
	Suspended Solids	Daily
	Volatile Solids	Daily
Digestion	Total Solids	Weekly
	Volatile Solids	Weekly
	pH	Daily
	Gas Analysis	Weekly
	Alkalinity	Weekly
	Volatile Acid	Weekly
Centrifuging	Suspended Solids	When in Operation
	Volatile Soilds	When in Operation
Vacuum Filters	Sludge Filterability	When in Operation
	Suspended Solids	When in Operation
	Volatile Solids	When in Operation
Incineration	Ash Analysis	When in Operation
	ADVANCED TREATMENT	
Chemical Coagulation & Flocculation	Jar Test	Weekly
	Phosphorus Analysis	Weekly
Activated Carbon	Apparent Density	Weekly
	COD	Weekly
	TOC	Weekly
Recarbonation	pH	Weekly
Ammonia Stripping	Amonia Nitrogen	Weekly
	pH	Weekly
Filters	Suspended Solids	Daily
	Turbidity	Daily
Microscreen	Suspended Solids	Daily
	Chemical Oxygen Demand	Weekly

Table III-2

EQUIPMENT TESTING MATRIX

Equipment Needed	Atomic Absorption 600 Degrees C Muffle Furnace 103 Degrees C Drying Oven Analytical Balance Imhoff Cone	pH Meter Lamotte Kit Biochemical Oxygen Demand Incubator Vacuum Pump Hot Plate Kjedahl Unit	Condenser & Extraction Equipment Dissolved Oxygen Meter & Probe Autoclave mperometric Titrator Sterilizing Oven	35 Degrees C Incubator Gas Analyzer Steam Bath Magnetic Stirrer Blender	Turbidity Meter Carbon Absorption Unit Desiccator Spectrophotometer Stirring Equipment	Vibrating Shaker Total Organic Carbon Analyzer Purity Meter Water Still
CONSTITUENTS TO BE ANALYZED						
Volatile Solids Total Solids Settleable Solids pH Total Sulfides						
Biochemical Oxygen Demand Chemical Oxygen Demand Suspended Solids Dissolved Oxygen Chlorine Residual						
MPN Coliform Volatile Acids Alkalinity Gas Analysis Grease						
Total Organic Carbon Turbidity Volatile Suspended Solids Total Phosphorous MBAS						
Sludge Filterability Ash Analysis Jar Test Apparent Density Iodine Number						
Isotherms Calcium Content Ammonia Nitrogen Organic Nitrogen Nitrate Nitrogen Heavy Metals						

*The equipment specified in this matrix is subject to plant size and complexity of processes and the degree of control required.

Types of Sampling

Sampling can be either of two types:

1. Grab This type of sample is taken when wastewater does not flow continuously, when appearance of discharge changes rapidly, and when making sure that the composite sample isn't masking extreme conditions of the waste.

   It is also used when test samples cannot be mixed, such as when testing for residual chlorine, dissolved oxygen, or pH.

2. Composite With the widely varying characteristics of waste, this type of sampling provides a representation of wastewater over a period of time and can be composited on the basis of proportional flow or the same amount being collected at every interval during the sampling period. Composites should be corrected as specified in Standard Methods.

Location of Sampling Points

Samples should be taken only where the wastewater is well mixed. If large particles are found in the sample, they should be broken up to make a more homogenous sample. Deposits or growths of floating material which have formed at the sampling point should not be included in the sample.

Quantity of Sample

In order to determine the correct amount of sample to be collected, the past flow records of the plant should be analyzed to determine the daily average flow. The amount of the composite sample to be collected at a given period should be proportional to flow of wastewater at that time. Then determine the quantity of sample needed for analysis; 1 liter is usually sufficient; never try to work with less than about 200 ml.

Handling and Storage of Samples

Samples should be tested as soon as possible. If testing must be delayed, then adequate storage must be provided. Table III-3 recommends appropriate storage temperature and duration in terms of the test to be performed on the stored sample.

Table III-3

STORAGE TEMPERATURE AND TIME 1/

ANALYSIS	TEMPERATURE	TIME	TEMPERATURE	TIME
Total Solids Suspended Solids	4 Degrees C 4 Degrees C	Up to Several days	0 Degrees C	No storage
Volatile Suspended solids	4 Degrees C	Up to several days	0 Degrees C	No storage
COD	4 Degrees	Up to several days	0 Degrees C	Unlimited
BOD		Up to one day in composite sampling systems		Lag develops, must use fresh sewage seed

Source: Agardy, F.J., and M.L. Kiado, Effects of Refrigerated Storage on the Characteristics of Waste, 21st Industrial Waste Conference, Purdue University, May 3-5, 1966.

1/ For more detailed preservation techniques see Analytical Quality Control, EPA Chemical Methods, or Standard Methods.

Test Records

In order that the data developed through the plant sampling program can be properly utilized to gage plant performance, it is necessary that it be systematically recorded and filed for ready reference. The most practical means of satisfying this requirement is to prepare convenient forms on which these data can be recorded. These forms should be prepared to fit the particular operating conditions at each individual plant. The data should be recorded chronologically on these forms and should be organized so that each set of data can be utilized to evaluate a particular aspect of the treatment process. Proper recording of sampling data will allow for more efficient and expedient solution of operational problems. Several examples of operational forms are included at the end of this section which can be utilized for the recording of analytical data pertinent to the treatment process.

In addition to recording the data on forms, graphing of pertinent operating parameters may be appropriate and desirable for visual presentation.

For additional information on sampling and testing, see:

State of Washington Wastewater Plant Operator's Manual
Operation of Wastewater Treatment Plants: A Field Study Training Program, EPA
Effects of Refrigerated Storage on the Characteristics of Waste, 21st Industrial Waste Conference, Purdue University
Standard Methods, 13th Ed Collection, Storage, Transportation and Pretreatment of Water and Wastewater Samples by Sanitation and Radiation Laboratory, California State Dept. of Public Health
MOP 11
MOP 18

(List MOE Phamplets - Courses
Sewage
Gas Chlorination)

SECTION 5

COMMON OPERATING PROBLEMS and SUGGESTED SOLUTIONS

(Waste water Treatment Plants)

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SEWAGE TREATMENT PLANT

COMMON OPERATING PROBLEMS

and

SUGGESTED SOLUTIONS

INTRODUCTION

There is a variety of common operating problems which may occur periodically and prevent the proper processing of wastes by a treatment plant.

The purpose of this section is to properly identify the problem by defining the indicators. Once the problem has been identified, certain monitoring, analyses and/or inspections must be performed prior to making a decision as to which corrective measures should be utilized. In some cases, the data-gathering process can be a simple visual observation and in other cases it can involve rather intricate sampling and laboratory procedures. The resulting information should then be systematically utilized to make a determination on which of the corrective measures should be implemented.

The problems discussed in this section are those which occur rather frequently in practice and the suggested solutions have been, for the most part, accepted procedure in the industry. There may be times when the suggested corrective measures do not correct the problem, or a problem may exist which does not fit into the common category. In a case such as this, it is prudent to seek expert advice on the subject prior to undertaking any course of action. The information utilized in development of the indicators and solutions reflect the present state-of-the-art; as information from new technical advances becomes available, this section will be updated.

1. PRETREATMENT - Pumping Plants and Influent Sewers

Problem SURGING OF PLANT INFLUENT

Indicators

1. Intermittent flooding of weirs and structures.
2. Plant efficiency treating wastewater drops sharply for short period of time.
3. Flow meter records intermittent high and low peak flows.
4. Excessive suspended solids in overflows.

Monitoring, Analysis and/or Inspection

1. If a main sewage lift station pumps effluent to plant, check for frequent starting and stopping of pumps or more than one pump operating at one time (out of phase) during a pumping cycle.
2. If influent flows to the plant by gravity through a main trunk, check depth of flow in connecting sewers if channel is uniform or monitor flow with a portable flow meter.
3. If surging occurs during rainfall, record relation of surging to duration of rainfall; and record or obtain rainfall intensity if possible.

Corrective Measures

1. Surging from gravity influent line indicates a major pump station discharge into a connecting sewer. Review water depth and/or portable flow meter data to determine source of flow.
2. Intermittent starting and stopping or recycling of main influent pump station or stations indicates improper wet well sensor adjustment or that the hydraulic capacity of the station has been exceeded. Adjust level sensors for a more desirable pumping cycle. If possible, install variable speed pump units for uniform flow into treatment plant; or install surge tank.
3. Heavy surging or hydraulic loading of treatment plant treating waste from a separated system during periods of normal rainfall indicates illegal connections to system such as catch basins, yard drain, or roof downspouts. "Smoke bomb" sanitary sewer system to determine source of illegal connections.
4. Heavy surging or hydraulic loading of treatment plant during period of heavy rainfall is caused primarily by flooding of street areas and water entering the system through manholes, broken lines, etc. Seal all manhole covers in high risk flood areas and patch all cracks in manhole structures with an epoxy water resistant compound.

I. PRETREATMENT - Pumping Plants and Influent Sewers

Problem

ACCUMULATION OF SOLIDS OR SCUM IN WET WELL

Indicators

1. Scum blanket in wet well
2. Odors
3. Improper operation of level sensing equipment

Monitoring, Analysis and/or Inspection

1. Sound wet well with a pole to determine solids level.
2. Measure wet well draw down during pumping cycle.
3. Ascertain relation of pump suction piping to floor of wet well.
4. Determine elevation of inlet piping.
5. Look for dead spots in corners and structural cracks where sludge can accumulate.

Corrective Measures

1. Start pumps manually, being careful not to break suction, and pump wet well down to lowest possible elevation while breaking scum blanket with a high pressure water hose.
2. Check pumping level and determine if more of a drawdown can be allowed for in order to remove more of the floatable materials.
3. If one or more influent line come in at a higher elevation than the pump suction inlet, set level sensor so drawdown will allow for spillage of fresh wastewater onto the scum blanket. The resultant turbulence could assist in breaking the blanket.
4. If this is a persistent problem install air diffusers in wet well with compressors wired to operate in tandem with the pumps. Diffused air will assist in placing the solids in suspension and curtail the development of a scum blanket.

I. PRETREATMENT - Pumping Plants and Influent Sewers

Problem ODOR SOURCE IN WET WELL

Indicators

1. Odors of hydrogen sulfide origin
2. Corrosion of iron work and concrete
3. Black color observed in liquid or solids

Monitoring, Analysis and/or Inspection

1. Hang hydrogen sulfide (lead acetate) indicator tiles in wet well.
2. Sample wastewater in wet well and analyze for total and dissolved sulfides.
3. Check for floating solids in wet well.
4. Run dye test on influent sewer or sewers to determine velocity of waste flow and travel time to wet well.
5. Check temperature of wastewater in wet well.
6. Check pump invert position and condition.
7. Check passage time in the interceptors at flow velocities.

Corrective Measures

1. Low velocities (less than 2 ft/sec) are an indication that solids are being deposited in influent sewer and sulfides are being formed and released in the wet well. Velocity must be increased in the sewer or influent must be continuously treated upstream with chlorine or copperous to prohibit the development of hydrogen sulfide gas.
2. If the source of hydrogen sulfide is in the wet well and not the influent sewer, increase pumping cycle for more frequent removal of solids.
3. Install air diffusers in wet well to keep wastewater fresh.
4. Install blower and gas scrubber for the oxidation of the gases and exhausting to the atmosphere.
5. Dose wet well with hyperchloride on a periodic basis to suppress the formation of hydrogen sulfide.

1. PRETREATMENT - Screening and Shredding

Problem

ACCUMULATION OF RAGS AND DEBRIS FOR DISPOSAL

Indicators

1. Large amount of rags and debris accumulated on plant site gives off obnoxious odors and attracts flies and other insects.

Monitoring, Analysis and/or Inspection

1. Estimate volume (cubic feet) of rags and debris removed each day in proportion to flow.
2. Determine time exposed material is allowed to accumulate.
3. Check disposal method used.

Corrective Measures

1. Arrange for local refuse or garbage company to pick up rags and debris on a daily basis and dispose of them in a sanitary fill.
2. Store rags and debris in closed containers whenever possible.
3. If incineration facilities are available on plant site or at some other convenient location, burn them. Care must be taken to see that the emission from the incinerator meets location air pollution control requirements.
4. Rags and debris can be disposed of on the plant site if sufficient land is available for a fill and cover operation.
5. If none of the above methods proves feasible, rags and debris can be ground up by installing the proper equipment and returned to the plant flow. This method should only be used as a last resort since ground or shredded screenings may cause problems in pumping equipment and in digesters.

I. PRETREATMENT - Screening and Shredding

Problem EXCESSIVE GRIT IN BAR SCREEN CHAMBERS

Indicators

1. Surging in chamber due to increase in water level.
2. Low removal of grit by degritting equipment.
3. Excessive dryout of grit with screening.

Monitoring, Analysis and/or Inspection

1. Sound chamber with flat board at end of pole to determine depth of grit.
2. Determine velocity in chamber by timing a dye release from one end of chamber to the other.
3. Check plans and probe bottom of chamber to determine whether there are any irregularities in chamber bottom slope.
4. Check channel when dewatering for regularly scheduled maintenance.

Corrective Measures*

1. If velocity in chamber is less than 2 ft/sec. flush chamber regularly with high pressure water hose. If slide gates are available at inlet end of chamber, throttle gates to jet flow along chamber bottom.
2. Remove irregularities or reslope chamber bottom; if possible, to increase velocity.
3. Regulate velocity in grit chamber by utilizing different outlet weir shapes.

*NOTE: Often this situation is created by a problem in the design so the operating staff are limited in the steps they can undertake in an effort to improve the situation.

1. PRETREATMENT - Screening and Shredding

Problem	ODOR SOURCE IN GRIT CHAMBER
Indicators	1. Odors of hydrogen sulfide origin 2. Corrosion of metal work and concrete
Monitoring Analysis and/or Inspection	1. Hang hydrogen sulfide (lead acetate) tiles in chamber. 2. Check velocities through grit chamber. 3. Check volatile solids content of the grit. 4. Sample wastewater in chamber and analyze for total and dissolved sulfides. 5. Check for floating solids in chamber. 6. Measure depth of grit in chamber. 7. Check for submerged rags and debris on bar screen.
Corrective Measures	1. Clean bar screen thoroughly so as not to impede flow. 2. Increase velocity to 1 fps. 3. Wash grit chamber thoroughly daily with high pressure water hose to move sludge and floating solids through screens.

1. PRETREATMENT - Screening and Shredding

Problem SHREDDED SCREENINGS, CLOGGING PUMPS

Indicators

1. Rope-like rags and debris wrapped around pump impellers.
2. Pump suction lines plugged with "bundles" of rags.
3. Excessive pump or drive beating and power requirements.
4. Appearance of chunks larger in size than usual in the shredder discharge.

Monitoring, Analysis and/or Inspection

1. Install pressure gages on discharge side of pump and check pressure daily.
2. If pump discharge line visible, check flow daily.
3. Check power input, bearing heat pressures on inlet and discharge sides.
4. Check driver speed and power train for power use and delivery to the shredder.

Corrective Measures

1. Do not shred screenings and return them to flow. Remove them either mechanically or manually and dispose of them by burial.
2. Check cutters periodically on all barminutors, comminutors, and other shredding equipment for sharpness.
3. Back flush pumps, periodically if possible.
4. If necessary, modify pump type, inlet protection or prior protective devices to avoid recurred plugging.
5. Upgrade screening and grit removal operation.

1. PRETREATMENT - Grit Handling and Removal

Problem

GRIT REMOVED HAS HIGH ORGANIC CONTENT

Indicators

1. Grey color of grit
2. Odors from grit
3. Greasy feel with excessive components

Monitoring, Analysis and/or Inspection

1. Run volatile solids test on grit daily.
2. Check discharge pressure on cyclonic grit removal equipment.
3. Check velocities with dye releases in grit chambers.
4. If grit chamber is aerated, check air flow rate to chamber.
5. Visual examination of grit and identification of origin of grit materials.

Corrective Measures

1. Keep pressure on cyclonic grit removal equipment at an acceptable range (usually between 4 and 6 psi) by governing pump speeds.
2. Increase velocities in grit chambers by whatever means possible.
3. Adjust air accordingly.
4. Check inlet and outlet controls, baffles and mechanical equipment; adjust and repair and keep clean.

1. PRETREATMENT - General

Problem

INDUSTRIAL WASTE IS INADEQUATELY PRETREATED

Indicators

1. Discoloration of influent
2. Sterilization of biological treatment processes
3. Digester upsets
4. Change in influent odor
5. Unusual amounts of solids in influent

Monitoring, Analysis and/or Inspection

1. Constantly monitor influent for pH above 8.0 or below 6.0.
2. Check pH of raw sludge.
3. Run heavy metal tests on influent.
4. Check influent temperature.
5. Run settleable solids test.
6. If toxic flow is constant, attempt to trace source upstream of treatment plant.
7. Run C.O.D. test on contaminated effluent and compare results with normal plant loading.

Corrective Measures

1. Determine the nature of the contaminant, locate source and have it discontinued. Determine quantity directed to the plant.
2. Consult MOE experts and literature to determine appropriate corrective actions.
3. If digesters show increases in volatile acids because of contaminated sludges, see Section VII (b) for corrective measures.
4. If activated sludge process has become contaminated and biological process has stopped, dispose of floc and re-start process.
5. Institute program of source control (industrial waste ordinances).

II. PRIMARY TREATMENT - Primary Sedimentation Tanks

Problem — FLOATING, GASEOUS, OR SEPTIC SLUDGE IN TANKS

Indicators

1. Floating material in tank deadspots or in scum troughs
2. Odors of hydrogen sulfide origin

Monitoring, Analysis and/or Inspection

1. Run total solids tests on raw sludge being pumped from primary sedimentation tanks with sample being taken at beginning and end of pumping cycle.
2. Dewater tanks and check sludge collector mechanism (flights, chains and scrappers) for wear and tear.
3. Observe conditions of tanks prior to chemical treatment of tank influent.

Corrective Measures

1. If total solids of raw sludge analyzed at end of pumping cycle is over 2%, increase duration of pumping cycle, preferably with a timer.
2. If sludge collector mechanism shows signs of wear during inspection, repair or replace.
3. Certain chemicals, such as alum, used in chemical treatment, cause floating sludge if this chemical is recirculated to the primary sedimentation tanks. Change operating procedures or chemicals used.
4. Long detention in sludge hoppers favors production of a sludge that readily slips.

Problem LOW SETTLEABLE SOLIDS REMOVAL EFFICIENCY

Indicators

1. Floating and gaseous sludges in tanks
2. Percent settleable solids removal below 95%

Monitoring, Analysis and/or Inspection

1. Run settleable solids test (Imhoff Cone) during times of day where there are appreciable changes in plant flow.
2. Check raw sludge removal pumping cycles and duration of pumping period.
3. Run total solids test on raw sludge removed from tanks both at beginning and end of pumping cycle.
4. Dismantle and/or inspect raw sludge pumps and sludge collection mechanism for wear and tear.
5. Check tank inlets with relation to the tank outlets. If baffles have been installed on the inlets, dewater the tanks and check their condition.
6. Calculate theoretical detention time, weir overflow rates, and surface loading rates and compare all data with design criteria.
7. Try a dye test to estimate flow-through time. Check for density stratification due to significant temperature or density difference top to bottom.

Corrective Measures

1. If efficiency of removal drops during peak or increased plant flows, the hydraulic capacity of tanks has probably been exceeded. Refer problem to operating agency engineering staff.
2. Repair all worn raw sludge pumps, parts and sludge collector mechanism.
3. Damaged or missing inlet line baffles could cause tank short circuiting whereby increased velocities from one end of the tank to the outlet end cause settleable matter to remain in suspension. Replace or repair baffles.

II. PRIMARY TREATMENT - Primary Sedimentation Tanks

Problem ERRATIC OPERATION OF SLUDGE COLLECTION MECHANISM

Indicators

1. Frequent replacement of broken sheer pins on chain driven collector mechanisms.
2. Frequent torque switch activated alarms on concentric driven clarifier equipment.
3. Visible slippage or "stuttering" of clarifier sludge collection mechanisms.

Monitoring, Analysis and/or Inspection

1. Check all drives for gear wear.
2. Dewater tank and check chains and sprockets for wear and see that chains have not come off sprockets.
3. Check to see that rags and debris have not entwined themselves around sludge collector mechanism.
4. Check dewatered tanks for excessive bottom deposits of sand, rocks and other inorganic material.
5. Sound bottom for excessive accumulation of sludge.

Corrective Measures

1. Repair all worn sludge collector equipment and drives.
2. If rags are a problem, make provisions for removal of all rags and debris as part of the pretreatment process.
3. If sand and rock deposits on the tank bottom are a problem, provide adequate screening and grit removal as a part of the pretreatment process.
4. If sludge accumulation is a problem, increase frequency of pumping raw sludge from tanks.

II. PRIMARY TREATMENT - Primary Sedimentation Tanks

Problem LOW SCUM (GREASE) REMOVAL*

Indicators

1. Visible grease particles being discharges in plant effluent.
2. Excessive water in scum pits.

Monitoring, Analysis and/or Inspection

1. Run grease test (composite) on plant influent and effluent and calculate efficiency of grease removal equipment and compare with plant design criteria.
2. Observe if wooden flights making a return travel on tank surface carry grease particles adhered to them under scum troughs at the discharge end of the tanks.
3. Determine, with a pole, the depth of floating scum and water in scum pits.
4. Check capacity of scum pits.
5. Check for wear of scum pickup wiper blades.

Corrective Measures

1. If possible, lower return wooden flight to below water surface so grease particles do not adhere to them.
2. Install water sprays to direct grease particles on tank surface into scum troughs. Water spray should not break surface tension on water surface.
3. If scum removal is done manually and intermittently, continuous removal equipment should be installed.
4. Excessive water in scum pits should first be removed by pumping from bottom of pit to plant headworks and then the concentrated scum can be pumped to a digester or an incinerator.
5. Efficiency of scum removal in plants receiving a high grease loading can be increased by the addition of floatation or evacuator equipment.
6. Since grease particles normally in suspension tend to agglomerate into larger particles after being dosed with chlorine, chlorine contact tanks should be provided with grease removal equipment.
7. Pump scum pits down on a regular basis so as not to cause scum overflows back into the clarifier.
8. Clean and replace all worn wiper blades.

*NOTE: Wastewater temperatures in the activated sludge process can have some effect on sedimentation and biological activity. It is generally known that as temperature decreases liquid viscosity increases; consequently, some adverse effect upon secondary clarifier sedimentation may be experienced during winter months.

II. PRIMARY TREATMENT - Primary Sedimentation Tanks

Problem — TANK CONTENTS TURN SEPTIC

Indicators

1. Tank contents are a dark color
2. Hydrogen sulfide odors emitted from tanks

Monitoring, Analysis and/or Inspection

1. Run total and dissolved sulfide tests on both tank influent and contents.
2. Run DO test.
3. Check pH of tank influent.
4. Check quantity and total solids of all inflows into tank from other plant processes such as digesters supernatant, thickener overflows, centrifuge concentrates, etc.

Corrective Measures

1. If tank influent contains high dissolved and total sulfides, influent is septic. Prechlorinate influent or correct problem at source.
2. If tank influent pH is below 6 or above 8, toxic waste is being discharged into plant and must be corrected at the source.
3. If discharges from other plant processes contain excessive total solids and exceed 5% of the daily tank inflow, the sedimentation tank is being overloaded. If possible, reduce rate of process flows to sedimentation tanks or pretreat flows by aerating or chlorinating them. If possible divert or find other means of disposal for supernatant or centrates.

Problem SLUDGE BULKING

Indicators

1. Rising sludge in final clarifiers
2. Floating matter being discharged in final effluent
3. Filamentous growths in mixed liquor

Monitoring, Analysis and/or Inspection

1. Check mixed liquor for low pH and low dissolved oxygen.
2. Check sludge age, food/micro-organism ratio, or mean cell residence time.
3. Run settleability test and check for separation of floc in graduated cylinder or use Mallory Direct Reading Settleometer.
4. Check aeration period.
5. Check for NO_2 and NO_3.

Corrective Measures

1. If possible, reduce organic loads on aeration tanks affected.
2. Add digested sludge (that has been aerated for some time) to aeration tanks.
3. Dose the aeration tanks with alum or ferric chloride together with lime.
4. Controlled chlorination of return activated sludge.
5. Reduce sludge age and air rate to stop nitrification.
6. Increase sludge age by regulating waste sludge rate.
7. Increase or correct low dissolved oxygen or pH in aeration tank.
8. Increase aeration period by placing another aerator in operation if possible or reduce the return sludge rate by thickening the return sludge concentration by coagulation.
9. Control filamentous growth by increasing sludge age or supplementing nutrient deficiencies.
10. If nitrification is desired, maintain a minimum of 3 mg/l NO_3 and a maximum of 1 mg/l NO_2.

III. SECONDARY TREATMENT - Activated Sludge Process

Problem	ERRATIC SLUDGE VOLUME INDEXES
Indicators	1. Pin floc visible in final clarifiers overflow 2. Poor settling characteristics of mixed liquor
Monitoring, Analysis and/or Inspection	1. Check mixed liquor suspended solids in each aeration tank. 2. Run 30 minutes settleability test in each aeration tank. 3. Determine whether the point floc is a recurrent situation or the result of toxicants.
Corrective Measures	1. Regulate wasting to decrease suspended solids in mixed liquor. 2. Chlorinate return activated sludge. 3. Decrease solids loading to aeration tanks. 4. Make appropriate adjustments to obtain a less oxidized sludge.

III. SECONDARY TREATMENT - Activated Sludge Process

Problem

DIFFICULTY IN MAINTAINING BALANCED MIXED LIQUOR AND DISSOLVED OXYGEN IN AERATION TANK

Indicators

1. Intermittent sludge bulking
2. Loss of sludge blanket in secondary clarifier
3. Dark color in the aerator contents

Monitoring, Analysis and/or Inspection

1. Check D.O. concentration in different areas of aeration tanks during changes in daily flow.
2. Check suspended solids in mixed liquor at different periods during the day.
3. Monitor rate of flow to aeration tanks.
4. Check daily flow variation in loading for excessive peak demand periods.

Corrective Measures

1. Lower D.O. concentrations occurring during changes in plant flow are an indication of excessive loading of aeration tanks. Increase air supply to tank if possible by placing another blower into service, etc.
2. Decrease loading to aeration tanks by placing more tanks into service if possible.
3. Increase inflow could hydraulically overload the secondary treatment system. If possible, bypass a portion of the flow from the primary sedimentation tank until the flow rate returns to normal.

Problem	EXCESSIVE FOAM IN AERATION TANKS
Indicators	1. Frothing in aeration tanks
Monitoring, Analysis and/or Inspection	1. Check influent for radical temperature changes. 2. Run M.B.A.S. test on influent. 3. Check suspended solids concentration in aeration tanks. 4. Check D.O. concentration in aeration tanks.
Corrective Measures	1. If practical, increase mixed liquor suspended solids by decreasing wasting rate. 2. Install or operate reclaimed water sprays in aeration tanks. 3. Utilize defoaming agent. 4. Lower air supply while being careful to maintain a safe dissolved oxygen concentration in aeration tanks.

Problem

DIGESTER SUPERNATANT AND/OR CENTRIFUGE CENTRATE UPSETTING ACTIVATED SLUDGE PROCESS

Indicators

1. Mixed liquor changes from a light to a dark brown color
2. Mixed liquor suspended solids decrease sharply during operation of centrifuge or when sludge is being pumped to digester
3. Final clarifier effluent increases in turbidity
4. Mixed liquid DO decreased.

Monitoring, Analysis and/or Inspection

1. Run total solids and pH tests on supernatant or centrate being returned to plant headworks.
2. Check mixed liquor suspended solids during discharge of centrate or supernatant.
3. Continuously check mixed liquor D.O.
4. Check volume of concentration of recycle flows relative to total plant flow.

Corrective Measures

1. Program discharges of supernatants or centrates so they do not coincide.
2. Pump centrates to digester whenever possible.
3. If centrates have high solids content, use flocculants in the operation of the centrifuge.
4. If supernatant have high solids content, experiment with supernatanting from a different level in the digester.
5. If possible, pre-aerate centrate and supernatants prior to discharging them to the activated sludge process.
6. Avoid discharging supernatants from septic digesters to activated sludge process.
7. If possible, release only small amounts of supernatant or centrate during periods of low inflow and increase return activated sludge rates if necessary.
8. Program recycles so that the return load does not exaggerate peak loading.

III. SECONDARY TREATMENT - Activated Sludge Process

Problem	UNABLE TO MAINTAIN BALANCED FOOD/MICRO ORGANISM RATIO IN AERATION UNIT
Indicators	1. Fluctuation in S.V.I. 2. Fluctuation in sludge age.
Monitoring, Analysis and/or Inspection	1. Check S.V.I. at least daily. 2. Check mixed liquor volatile suspended solids at least daily. 3. Check suspended solids in influent and effluent at least daily. 4. Monitor plant flow, return activated sludge rate, and waste activated sludge rate.
Corrective Measures	1. Select and operate secondary treatment system by food/micro organism ratio, or sludge age.

III. SECONDARY TREATMENT - Activated Sludge Process

Problem — FACILITIES INADEQUATE FOR DISPOSAL OF WASTE ACTIVATED SLUDGE (HIGH SUSPENDED SOLIDS IN THE CLARIFIER OVERFLOW)

Indicators

1. High suspended solids in mixed liquor
2. Increased turbidity in final clarifier effluent
3. High solids concentration in digester supernatants and sludge thickener effluents

Monitoring, Analysis and/or Inspection

1. Check S.V.I. at least daily.
2. Run C.O.D. and suspended solids of plant influent with and without supernatant and thickener return flows.
3. Check blanket depth level or high and low load periods.
4. Check inlet and outlet baffling for possibility of short circuiting.

Corrective Measures

1. If waste activated sludge is not settling in sludge thickener, increase flow of raw sludge to thickener or dose thickener inflow with coagulants.
2. Attempt to break "sludge cycle" by lowering wasting rate.
3. Re-aerate waste sludge prior to pumping to thickeners or discharging to primary clarifiers.
4. Change operation mode of aeration tanks to contact stabilization if possible.
5. If the sludge doesn't settle satisfactorily, coagulate with iron or aluminum, but adjust pH if necessary to keep aerator pH within 6.0-8.5.

III. SECONDARY TREATMENT - Activated Sludge Process

Problem — UNEVEN HYDRAULIC AND SOLIDS LOADING OF AERATION TANKS

Indicators

1. Mixed liquor suspended solids in each aeration tank varies considerably.
2. Dissolved oxygen in each tank varies considerably.

Monitoring, Analysis and/or Inspection

1. Run S.V.I. in each tank at least daily.
2. Run mixed liquor suspended solids in each tank at least daily.
3. Run dissolved oxygen in each tank at least daily.
4. Run suspended solids on influent and effluent.

Corrective Measures

1. Adjust valves and inlet gates to equalize flow to all tanks when operating under conventional mode.
2. Equalize air flow to all tanks by throttling valves on air discharge lines.

III. SECONDARY TREATMENT - Trickling Filters

Problem ICE BUILDUP ON MEDIA

Indicators

1. Visible ice formation on filter media

Monitoring, Analysis and/or Inspection

1. Check air temperature.
2. Check recirculation rate to filter.
3. Check flow through filter orifices.
4. Check temperature of wastewater flow to filter.
5. Check filter surface for even distribution of flow.

Corrective Measures

1. By regulating amount of recirculation rate, adjust flow to filter to prohibit the formation of ice.
2. Adjust flows from orifices and splash plates to reduce spray effects.
3. Cover filter to reduce heat losses or install a windbreak to reduce chill factor.
4. Manually break up and remove major ice formations.
5. If possible, add hot water or steam to filter influent.

Problem	FILTER ODORS
Indicators	1. Odors of hydrogen sulfide origin present 2. Black slime visible on surface of filter media
Monitoring, Analysis and or Inspection	1. Check dissolved and total sulfide of plant and filter influents. 2. Check filter drains for stoppages or growths. 3. Check rate of recirculation to filter. 4. Check for filter overflow or splashing.
Corrective Measures	1. If flow to filter is septic, correct in upstream system by aeration or controlled prechlorination. 2. Clear under drain system of all stoppages. 3. Force air into filter drain system to increase ventilation through filter media. 4. Increase recirculation rate to filter to increase D.O. and to slough off surface slime. 5. Keep areas around filters clean of slimes and growths. 6. Cover filter with inert material and exhaust air into an odor control/scrubber.

III. SECONDARY TREATMENT - Trickling Filters

Problem FLY NUISANCE IN VICINITY OF FILTER

Indicators

1. Tiny gnat sized flies becoming a nuisance in plant area and in neighboring area

Monitoring, Analysis and/or Inspection

1. Inspect grounds for tall grass, weeds and other sanctuaries for filter flies.

Corrective Measures

1. Increase rate of recirculation to filter to wash fly larvae out of filter.
2. If possible, flood filter for approximately 24 hrs. to prevent completion of life cycle of flies.
3. Apply a low dosage of chlorine being careful not to sterilize filter media.
4. Maintain grounds so as not to provide sanctuaries for flies.

III. SECONDARY TREATMENT - Trickling Filters

Problem CLOGGING AND PONDING OF FILTER MEDIA

Indicators

1. Ponding on filter surface
2. Intermittent flooding of filter

Monitoring, Analysis and/or Inspection

1. Check size of filter media for uniformity.
2. Check for cementing or breaking up of media.
3. Check for fibers, slime growths, trash, insect larvae, or snails in filter media voids.
4. Check organic loading on filter.
5. Check hydraulic load on filter.

Corrective Measures

1. If filter media is non-uniform and the smaller pieces fill the voids, replace the media.
2. Jet problem areas in filter media with a high pressure water spray from a stationary distributor.
3. Stir media manually to lessen or remove any accumulations.
4. Dose the filter media with chlorine at a rate of 5 mg/l for several hours a day during periods of low flow.
5. Flood filter media for approximately 24 hours to loosen surface accumulations.
6. Dry growth by drying filter for several hours, if possible.

Problem

CLOGGING OF DISTRIBUTOR NOZZLES CAUSES UNEVEN DISTRIBUTION OF FLOW ON THE FILTER SURFACE.

Indicators

1. Uneven sprays from distributor nozzles
2. Ponding on certain areas of the filter media with concurrent drying of other areas

Monitoring, Analysis and/or Inspection

1. Attempt to identify types or solids clogging nozzles.
2. Check for visible grease particles in waste being pumped to filter.
3. Run settleable solids test of waste being pumped to filter.

Corrective Measures

1. Remove and clean all nozzles and thoroughly flush distributor piping.
2. Improve primary clarifier skimming to prevent grease carryover to filter.
3. Increase detention time in primary tanks to prevent settleable and suspended solids carryover to filter.

III. SECONDARY TREATMENT - Oxidation Ponds

Problem EXCESSIVE WEEDS AND TULES

Indicators

1. Excessive weed and tule growths
2. Mosquito problems in neighborhood of ponds
3. Poor pond circulation

Monitoring, Analysis and/or Inspection

1. Check water depths in selected areas of the pond.

Corrective Measures

1. Deepen all pond areas shallower than three feet.
2. Remove all weed and tule growths as soon as they are visible.
3. For mosquito control, if problem persists after weeds have been removed, consult the Ministry of the Environment Pesticide specialists to investigate chemical control.

Problem	POND ODORS*
Indicators	1. Odors of hydrogen sulfide origin from pond 2. Other objectionable odors
Monitoring, Analysis and/or Inspection	1. Check for blue-green algae growths in pond. 2. Check for scum accumulation in pond. 3. Analyze for total and dissolved sulfides in pond and pond influent. 4. Check pond pH and pond influent pH. 5. Check DO content in pond at several locations.
Corrective Measures	1. If pond influent is septic, correct situation upstream by aeration or controlled prechlorination. 2. If possible, aerate pond with mechanical aerators. 3. Provide odor masking agent if feasible. 4. Prechlorinate pond influent. 5. If pond is septic, divert flow from aerobic pond to it or pump high D.O. make-up water to it.

*NOTE: In Ontario, lagoons often produce odors as the ice forms and breaks up on the liquid surface. Generally these conditions do not last more than a few days. Fortunately, there is little outdoor activity at these times, so there are few complaints.

III. SECONDARY TREATMENT - Oxidation Ponds

Problem	LOW POND DISSOLVED OXYGEN
Indicators	1. Low algae growth in pond 2. Trace hydrogen sulfide odors 3. Grey color of pond
Monitoring, Analysis and/or Inspection	1. Check all areas in pond for adequate D.O. 2. Monitor flow into pond and calculate average daily detention time in pond. 3. Check pH of pond influent and pond contents. 4. Run total and dissolved sulfides in pond influent. 5. Check pond loading rate (lb BOD/acre). 6. Check for floating aquatic weeds.
Corrective Measures	1. In the absence of adequate D.O. in the pond, aerate pond contents or pond influent. 2. Chlorinate pond influent if sulfides are present. 3. Physically remove floating weeds to increase light penetration.

Problem SLUDGE OR PIN FLOC FLOWING OVER WEIRS

Indicators

1. Particulate material rising to surface in clarifier
2. Effluent clarity poor

Monitoring, Analysis and/or Inspection

1. Check clarity of water in final clarifier with Secchi disc.
2. Measure turbidity of effluent discharged from clarifier with turbidimeter.
3. Attempt to determine height of sludge blanket in clarifier with depth sampler and/or a wooden pole.
4. Run suspended solids test on final clarifier effluent.
5. Check all sludge uptake piping to see that they are flowing freely and that 60% of the sludge removed is from inner 50% area of the clarifier.
6. Check pump rates and schedules of sludge withdrawal pumps.
7. Dewater clarifiers and check for damage on sludge scraper mechanism especially at the periphery of the tank.
8. Determine if the weir overflow rate is equal for the entire weir.

Corrective Measures

1. Increase pumping rate for greater removal of sludge from clarifier.
2. Wash down or clean all sludge uptake piping.
3. Repair or replace all damaged sludge scraper mechanism.
4. Level the weir.
5. If uneven weir overflow rate is caused from wind, install a windbreak.
6. Persistnece of this problem would indicate a malfunction in the secondary treatment process.

III. SECONDARY TREATMENT - Final Sedimentation

Problem	ERRATIC OPERATION OF SCRAPER MECHANISM
Indicators	1. Frequent torque switch activated alarms on concentric driven clarifier equipment 2. Visible slippage or "stuttering" of clarifier sludge collection mechanisms
Monitoring, Analysis and/or Inspection	1. Check all drives for gear wear. 2. Dewater tanks and check for true travel of scraper mechanisms.
Corrective Measures	1. Repair all worn sludge collector equipment and drives.

IV. ADVANCED TREATMENT - Chemical Coagulation and Flocculation

Problem

CHEMICAL COAGULANTS UTILIZED FOR SETTLING OR DEWATERING SLUDGES THROUGH RECYCLING CAUSE FLOATING SLUDGES IN PRIMARY SEDIMENTATION TANKS.

Indicators

1. Floating and gaseous sludge floating in primary sedimentation tanks during periods of chemical treatment
2. Poor settling characteristics in the sludge
3. Poor sludge dewatering characteristics.

Monitoring, Analysis and/or Inspection

1. Determine types and amounts of chemicals used.
2. Conduct laboratory jar tests to determine effect of recycled chemicals on wastewater.
3. Check the dosing sequence, the rapid mix energy, and flocculation energy.

IV. ADVANCED TREATMENT - Ammonia Stripping

Problem FREEZING IN AMMONIA STRIPPING TOWER

Indicators

1. Ice formation on outside face of tower
2. Drop in ammonia removal efficiency

Monitoring, Analysis and/or Inspection

1. Monitor ammonia removal
2. Check out water temperature for maximum and minimum values.
3. Check air circulation rate and distribution.

Corrective Measures

1. Use large flow distribution orifices at the outside face of the tower thus concentrating a curtain of warm water where the cold air first enters the tower.
2. Reverse draft fan to blow warm inside air outward to melt the ice.
3. If ammonia removal efficiency drops below 30%, take the tower out of operation.

Problem	FORMATION OF CALCIUM CARBONATE SCALE ON AMMONIA STRIPPING TOWER FILL AND STRUCTURAL MEMBERS
Indicators	1. Visible scale deposits in tower
Monitoring, Analysis and or Inspection	1. Check pH of tower influent (ph has to be 10.5 or greater.
Corrective Measures	1. Hose off scale with water jet at periodic intervals. 2. Install water sprays in tower for jetting off scale at frequent intervals. 3. Clean tower with light solution of sulfuric acid.

Problem	FILTER BACKWASH WASH WATER HYDRAULICALLY OVERLOADS AND UPSETS CLARIFIERS
Indicators	1. Surging of clarifier during filter backwash operation 2. Higher turbidity in the treated flow
Monitoring, Analysis and or Inspection	1. Determine amount and rate of filter backwash water being recycled to clarifiers. 2. Increase drum speed, backwash pressure or temperature, and backwash rate.
Corrective Measures	1. Collect backwash wastes in a storage tank and recycle at a controlled rate to clarifiers.

IV. ADVANCED TREATMENT - Microscreen

Problem

FOULING OF FABRIC WITH GREASE AND SOLIDS

Indicators

1. Loss of microscreen efficiency
2. Visible solids and grease on fabric

Monitoring, Analysis and/or Inspection

1. Run suspended solids test on influent to screen.
2. Check for upset in activated sludge process, if any.

Corrective Measures

1. Increase speed of drum.
2. Increase backwashing pressure.
3. Adjust backwashing cycles.
4. Backwash with hot water.
5. Backwash with an approved degreasing agent.

IV. ADVANCED TREATMENT - Microscreen

Problem	MICROSCREEN EFFLUENT EXHIBITS HIGHER SUSPENDED SOLIDS CONTENT THAN INFLUENT.
Indicators	1. Increased suspended solids and turbidity on discharge side of screens.
Monitoring, Analysis and/or Inspection	1. Determine colloidal solids in the influent to microscreens. 2. Determine total solids removal efficiency of microscreens. 3. Determine C.O.D. removal efficiency of microscreen.
Corrective Measures	1. Convert colloids in microscreen influent to suspended solids by adjusting the pH accordingly or by the addition of coagulants.

IV. ADVANCED TREATMENT - Activated Carbon

Problem MECHANICAL FOULING OF COLUMNS

Indicators

1. The flushing of accumulated solids from carbon columns is followed by an abrupt increase in the rate of absorption
2. Pressure rises in downflow columns
3. Decrease in flow rate.

Monitoring, Analysis and/or Inspection

1. Run suspended solids and total organic carbon of column influent and effluent.
2. Check for upset in secondary treatment process.
3. Check column operating routine and backwash records.

Corrective Measures

1. Bypass column influent with large amounts of suspended matter.
2. Flush columns frequently.
3. Consider upflow operation, filtration, or larger carbon grain size.

Problem

INSUFFICIENT CHLORINE GAS PRESSURE AT THE CHLORINATOR WITH ALL CYLINDERS CONNECTED TO GAS PHASE

Indicators

1. Chlorine pressure gage at chlorinator is reading too low.
2. Chlorine supply lines from cylinders are either very cold or are icing.
3. Chlorine cylinders or cylinder show a frost line.

Monitoring, Analysis and/or Inspection

1. Reduce feed rate on chlorinator to about one-tenth the rotameter capacity.
2. If after a short period the chlorine gas pressure rises appreciably, it can be concluded that the rate of feed through the chlorinator is greater than the evaporation rate of the chlorine cylinders or cylinder at the prevailing ambient temperature.

Corrective Measures

1. Connect enough cylinders to the supply system so that the chlorine feed rate does not exceed the withdrawal rate of the cylinders. For 150 lb. cylinders the withdrawal rate at room temperature is 40 lbs. per day per cylinder; for ton containers it is 400 lbs. per day. At lower temperature it is less.
2. If insufficient cylinder capacity exists, do not try to apply heat directly to the cylinders, and do not heat the chlorine storage room with a space heater unless the control equipment (chlorinator) room can be brought to the same temperature.
3. The chlorine cylinder should always be kept cooler than the control equipment if possible; otherwise reliquefaction of chlorine may occur at the chlorinator, "or where chlorine lines enter a cooler atmosphere."
4. Use of a large fan directing flow of room air at the cylinders will greatly increase heat absorption of cylinders resulting in greater gas production per cylinder.
5. If ton container, consider installation of an evaporator.
6. Installation of a press reducing valve immediately after cylinder header will control reliquefaction even though some temperature changes are present.

Problem: INSUFFICIENT CHLORINE GAS PRESSURE AT THE CHLORINATOR

Indicators:

1. Chlorine pressure gage at chlorinator is reading too low.
2. Chlorine supply lines from cylinders are either very cold or are icing.
3. There is icing or considerable cooling at one point in the chlorine header system between the cylinders and chlorinator.

Monitoring, Analysis and/or Inspection:

1. Reduce feed rate on chlorinator to about one-tenth the rotameter capacity.
2. If icing condition or cooling effect does not disappear, mark the point where cooling begins and secure the chlorine supply system at the cylinders, but let the chlorinator continue to operate.

Corrective Measures:

1. When chlorine gas pressure at chlorinator reaches zero and with chlorinator still operating, disconnect flexible connection to one chlorine cylinder. (This will allow chlorinator to evacuate residual chlorine in header system by replacing chlorine with air).
2. Disassemble chlorine header system at point where cooling began. A stoppage or a flow restriction will be found at or near this point.
3. After the stoppage has been found it can be cleaned with a solvent such as tri-chlorethylene.
4. For massive build-up in black steel pipe header systems, the pickling process should be used. This consists of isolating the header system by disconnecting it from the cylinders at one end, the chlorinators at the other, and flushing with cold water until the water coming out is clear. The header then has to be dried with steam or hot air and final air drying to a dew point of -40 degrees F.
5. When changing cylinders, air should not be allowed to enter the chlorine header and manifold system. Moisture will be drawn from the air by the chlorine trapped on the pipe walls, forming acid and causing corrosion.

V. DISINFECTION - Chlorination

Problem

THERE IS NO CHLORINE GAS PRESSURE AT THE CHLORINATOR, WHEN APPARENTLY FULL CHLORINE CYLINDERS ARE CONNECTED TO THE CHLORINE SUPPLY SYSTEM. ROTAMETER SHOWS ZERO FEED RATE.

Indicators

1. Chlorinator gas pressure gage is at zero, inlet valve is open, all valves beginning with chlorine cylinder valve to the chlorinator are open.

Monitoring, Analysis and/or Inspection

1. Close off water supply to the injector.
2. Check the external chlorine pressure reducing valve installed just downstream of the chlorine cylinders.

Corrective Measures

1. If normal chlorine pressure appears at the chlorinator secure all the main chlorine cylinder valves, and start ventilating fans if available and arrange for maximum ventilation. "Open water supply to injector until gas pressure reaches zero" - go to step 4. If pressure cannot be released in this manner, go on to step 2.
2. Put on a gas mask and gingerly break one flexible connection joint to release the gas in the header system.
3. Place a bottle of ammonia on the floor near the connection to be broken and when a white vapor appears leave the area as fast as possible and return only when the vapor disappears.
4. Repair the reducing valve which is probably plugged from the inherent impurities in chlorine gas. These units should be put on bi-annual overhaul.
5. Install a chlorine gas pressure gage upstream of the pressure reducing valve.
6. Consider installation of trap-filter upstream of P.R.V.

Problem

IMPOSSIBLE TO OPERATE CHLORINATOR BECAUSE ROTAMETER TUBE ICES OVER AND FEED RATE INDICATOR IS EXTREMELY ERRATIC. CHLORINE SUPPLY IS FROM TON CONTAINERS CONNECTED TO THE GAS PHASE.

Indicators

1. There is sufficient chlorine gas pressure and injector vacuum and the chlorine is at room teperature but the rotameter tube that indicates chlorine feed rate is nearly completely iced over.
2. The entire chlorine supply line back to the cylinder is also iced over, but cylinders are at about ambient temperature. NOTE: This indicator may not show up until corrective measure #1 is put into effect.

Monitoring, Analysis and/or Inspection

1. Inspect the chlorine cylinder area to see if they are connected properly. (This problem is specific to ton containers.)

Corrective Measures

1. Shut off main outlet valve on all cylinders and evacuate chlorine in header system until gage pressure at chlorinator reads zero.
2. Disconnect the cylinder that had icing on the flexible connection to the outlet valve and rotate it 180 degrees and reconnect to top outlet valve and with other cylinders closed place this one in operation.
3. Tag cylinder so that packager can identify it as defective with possible broken dip tube but allow cylinder to remain in use until empty.

V. DISINFECTION - Chlorination

Problem

CHLORINATOR WILL NOT FEED ANY CHLORINE EVEN THOUGH ALL SYSTEMS APPEAR NORMAL.

Indicators

1. Chlorinator feed rate indicator shows little or no indication of chlorine flow when chlorine control valve is moved from closed to wide open position.
2. The chlorine pressure gage in the chlorinator is normal but the injector vacuum gage shows an abnormally high vacuum.

Monitoring, Analysis and/or Inspection

1. Check for an obstruction in the chlorine gas line near or at the inlet cartridge of the chlorine pressure reducing valve inside the chlorinator by shutting off chlorine supply system at chlorinator; chlorine pressure gage remains the same or moves downward in pressure at a very slow rate, i.e., one division per five minutes.

Corrective Measures

1. Shut off chlorine supply at the cylinders and try to let the chlorinator drain off all the chlorine gas pressure in the chlorine supply line.
2. If this cannot be done, turn on the ventilating equipment in the chlorine container space, if any, open all windows, don a gas mask and break a connection in the chlorine supply header but be absolutely sure that all chlorine cylinders have been secured.
3. When the gas has sufficiently cleared intself from the working area, disassemble the chlorinator chlorine pressure reducing valve to remove inlet cartridge and clean stem and seat with a soft cloth.
4. If this situation occurs regularly during hot weather, the source of the trouble usually is a result of the chlorine cylinders being hotter than the chlorine control apparatus.
5. Inspect cylinder area to see if anything can be done to make the area cooler.
6. Do not connect a new cylinder if it has been allowed to sit in the sun.
7. Install an external chlorine pressure reducing valve adjacent to the last chlorine cylinder connected to the supply system.
8. Precede the reducing valve by a combination chlorine filter and sediment trap.

NOTE: Cylinders should be used only until they have lost the total weight of Chlorine. If they are drawn down until the full chlorinator vacuum is pulled on the cylinder, any foreign material within the cylinder will boil, and suspended particles will be drawn into the chlorine system eventually causing blockage.

Problem

CHLORINE GAS IS LEAKING FROM VENT LINE CONNECTED TO EXTERNAL CHLORINE PRESSURE REDUCING VALVE (CPRV).

Indicators

1. There is no visible indication of a malfunction.
2. Chlorine escaping from CPRV vent line.
3. Chlorine gas pressure, chlorine feed rate and injector vacuum are all normal.

Monitoring, Analysis and/or Inspection

1. Confirm leak by placing ammonia bottle near the termination of the CPRV vent line.

Corrective Measures

1. The symptom described indicates that the main diaphragm of the CPRV has been ruptured.
2. Remove the external CPRV after evacuating header system and replace with a jumper tube for temporary operation while valve is being repaired.
3. Disassemble valve and replace diaphragm.
4. Inspect the ruptured diaphragm to see if failure is from corrosion, improper assembly or just fatigue from length of service.
5. Consult manufacturer for expert opinion.
6. If failure is from corrosion the chlorine supply system should be inspected for moisture intrusion.

V. DISINFECTION - Chlorination

Problem

INABILITY TO MAINTAIN CHLORINE FEED RATE WITHOUT ICING OF CHLORINE SUPPLY SYSTEM BETWEEN EXTERNAL CHLORINE PRESSURE REDUCING VALVE AND CHLORINATOR. (EQUIPMENT CONSISTS OF EVAPORATOR, EXTERNAL CPRV AND THE CHLORINATOR.)

Indicators

1. Noticeable cooling of gas line to chlorinator beginning at outlet of external chlorine pressure reducing valve.
2. Evaporator water bath temperature is normal: 160 to 180°F.
3. Further cooling at point of pressure reduction in chlorine pressure reducing valve in chlorinator assembly.
4. Deposit of "gunk" on chlorinator feed rate indicator tube and what appears to be droplets of an amber color liquid.

Monitoring, Analysis and/or Inspection

1. Reduce feed rate on chlorinator to about 75 percent of evaporator capacity. If this or further reduction of feed rate eliminates the above symptoms, the difficulty is most likely to be insufficient evaporator capacity.
2. If chlorine gas temperature is available, calculate the superheat. If there is less than 5°F of superheat, there is very little reserve capacity in the evaporator. This is the result of an accumulation of sludge in the bottom of the liquid chlorine vessel of the evaporator.

Corrective Measures

1. Check for stoppage in the external CPRV cartridge if superheat cannot be measured.
2. Take the evaporator out of the system, flush and clean it with cold water and dry it in accordance with the manufacturer's instructions utilizing an "Evaporator Cleaning Kit." All evaporators should be routinely cleaned after passage of 250 tons of liquid chlorine.

V. DISINFECTION - Chlorination

Problem

CHLORINATION FACILITY CONSISTING OF EVAPORATOR-CHLORINATOR COMBINATION WITH EXTERNAL CHLORINE PRESSURE REDUCING AND SHUT-OFF VALVE IS UNABLE TO MAINTAIN WATER-BATH TEMPERATURE SUFFICIENT TO KEEP EXTERNAL CHLORINE PRESSURE REDUCING VALVE IN OPEN POSITION.

Indicators

1. External chlorine pressure reducing valve shuts off intermittently until water bath temperature is raised above 150°F.
2. Intermittent operation of chlorination equipment
3. Insufficient heat being supplied to evaporator water bath.

Monitoring, Analysis and/or Inspection

1. Check evaporator water bath temperature.

Corrective Measures

1. After evaporator has been in operation sufficiently long enough to bring heating elements to operating temperature, shut down power supply and remove and replace heating elements.

V. DISINFECTION - Chlorination

Problem

INABILITY TO OBTAIN MAXIMUM FEED RATE FROM CHLORINATOR OR CHLORINATORS WITH ADEQUATE CHLORINE GAS PRESSURE AT CHLORINATOR

Indicators

1. Chlorinator is placed into manual control and control valve is opened wide but chlorine feed rate will not go beyond 70 to 80 percent of maximum.
2. Check injector vacuum gage to see if reading is less than minimum recommended by manufacturer.
3. Check for injector vacuum reading below ten inches Hg.

Monitoring, Analysis and/or Inspection

1. Reduce feed rate on chlorinator.
2. If the injector vacuum reading increases then increase the injector water pressure.
3. Verify whether or not inlet water pressure to the injector is the same as when the installation was first installed.
4. Check injector water pump pressure against the manufacturer's operating data.
5. Check for excessive back pressure on solution discharge line (our spsi).

Corrective Measure

1. Disassemble injector and see that the throat and tailway are clear and without any abnormal deposition of iron or manganese, and clean the injector parts by soaking in nuriatic acid, rinse in fresh water and replace.
2. Relieve back pressure by cleaning or replacing pipe, diffusor etc. as required.

Problem INABILITY TO MAINTAIN ADEQUATE CHLORINE FEED RATE

Indicators

1. Inspection of chlorinator reveals that chlorinator cannot feed as much as previously noted even though chlorine supply pressure is adequate.

Monitoring, Analysis and/or Inspection

1. If effluent is used check the injector operating water supply for deterioration in supply pump performance.
2. Check for excessive back pressure on solution discharge line (over spsi).

Corrective Measures

1. In the case of a centrifugal pump the only solution is a complete overhaul.
2. If a turbine pump, close down on the needle valve to maintain the proper discharge pressure.
3. If the turbine pump has worn sufficiently and it requires operation with the needle valve in the fully closed position, the pump should be thoroughly overhauled.
4. Relieve excessive back pressure by cleaning or replacing pipe, diffuser etc. as required.

V. DISINFECTION - Chlorination

Problem

INABILITY TO OBTAIN MAXIMUM OR PROPER FEED RATE FROM CHLORINATOR WITH ADEQUATE GAS PRESSURE AT CHLORINATOR

Indicators

1. With chlorinator in manual control and chlorine control valve is manipulated to vary the feed rate, the change of feed rate response seems sluggish and chlorinator will not achieve maximum feed rate.
2. The injector vacuum reading is borderline, and when feed rate is reduced the injector vacuum does not increase appreciably.

Monitoring, Analysis and/or Inspection

1. Check the chlorinator vent system for a small vacuum leak in the chlorine control apparatus by disconnecting the vent line at the chlorinator and while observing the chlorinator operation (feed rate and injector vacuum), place a hand over the vent connection to the vacuum relief device on the chlorinator. If this action produces more injector vacuum and more chlorine feed rate, it signifies that air is entering the chlorinator via this mechanism (vacuum relief device) because the springs have become weak due to normal metal fatigue.
2. Moisten all joints subject to a vacuum with ammonia solution or put paper impregnated with orthotolidine at each of these joints. With chlorinator operating at maximum feed rate, close the injector discharge line as rapidly as possible. If there is a vacuum leak in the chlorinator system it will be detected by either the ammonia or the paper.
3. Check for excessive back pressure on solution discharge line.

Corrective Measures

1. If the vacuum leak is in the vacuum relief device, disassemble the mechanism and replace all the springs.
2. Repair all other vacuum leaks by tightening a joint, replacing gaskets, replace tubing and/or compression nuts.
3. Relieve excessive back pressure by cleaning or replacing pipe, diffuser etc. as required.

Problem EXCESSIVE CHLORINE ODOR AT POINT OF APPLICATION

Indicators

1. Air cover above area of chlorine diffuser reacts with ammonia solution to produce typical white wisps of "smoke" indicating escaping molecular chlorine.

Monitoring, Analysis and/or Inspection

1. Scattering ammonia indicator solution onto the wastewater stream over the area of the diffuser produces white fumes at the surface.
2. Check chlorine solution strength.
3. Check depth of chlorine diffuser below surface of wastewater stream (it should be 3-4 feet).

Corrective Measures

1. Add enough injector water to bring the chlorine solution strength down to 3500 ppm chlorine at maximum expected chlorine feed rate.
2. If the chlorine diffuser is situated below the injector which leads to a negative head in the solution line, install a special diaphragm protected chlorine solution pressure gage in the highest point of the chlorine solution discharge line and regulate the injector water flow so that there is a 2 to 3 psi positive pressure at this point.

V. DISINFECTION - Chlorination

Problem

CHLORINATOR WILL NOT FEED ENOUGH CHLORINE TO PRODUCE A PROPER CHLORINE RESIDUAL AT THE SAMPLING POINT.

Indicators

1. A routine spot check sampling shows that at some hours of the day there is an adequate residual but there are times during the day when there is no residual.
2. If there is a chlorine residual analyzer the chart will show periods during the day of insufficient chlorine residual.

Monitoring, Analysis and/or Inspection

1. Ascertain that if the chlorination equipment is being used for disinfection that it is equipped to proportion the chlorine feed rate in accordance with the flow of the wastewater.
2. If it is flow proportional, check to see if the meter capacity on the chlorinator matches the plant flow meter capacity.
3. Disconnect the flow proportional control and by manual control test the chlorinator to see if it will pull maximum feed rate.
4. Determine if solids have settled to the bottom of the contact chamber.

Corrective Measures

1. The automatic control features of the chlorinator should be repaired by the manufacturer's field service personnel who are equipped to simulate the various types of electric and pneumatic signals commonly used for chlorinator control.
2. If needed, clean the chlorine contact chamber.

Problem

WIDE VARIATION IN CHLORINE RESIDUAL IN EFFLUENT AS DETERMINED BY HOURLY CHLORINE RESIDUAL DETERMINATIONS

Indicators

1. Inability to adjust dosage so that there is reasonable agreement of chlorine residual throughout a 24-hour period as determined by occasional chlorine residual analysis at each shift.

Monitoring, Analysis and/or Inspection

1. While in flow proportional operation the feed rate of the chlorinator should be plotted on a piece of graph paper against the flow meter reading. The plots of wastewater flow versus chlorine feed rate should yield a straight line.

Corrective Measures

1. If the feed rate plots do not follow a reasonably straight line, it is well to recheck the zero and span of the flow proportional control device on the chlorinator. First make the zero check and then the span check in accordance with the manufacturer's instructions. If this does not correct the difficulty, it may be necessary to replace operating parts within the controller to achieve satisfaction.
2. If after the flow proportional control system on the chlorinator has been corrected the irregular chlorine residual reading continues, then it is recommended that a continuous chlorine residual analyzer be installed.

Problem

CHLORINE RESIDUAL ANALYZER RECORDER CONTROLLER DOES NOT APPEAR TO CONTROL THE CHLORINE RESIDUAL PROPERLY.

Indicators

1. Recorder draws a poor line on the chart that seems not to bear any relation to the "set point."

Monitoring, Analysis and/or Inspection

1. First check the loop-time in the system. This is best accomplished by turning off the gas supply to the chlorinator and determining the length of time required to show a sharp drop in the residual on the analyzer chart.
2. Disconnect the analyzer cell output leads from the cell and apply a simulated signal to the recorder mechanism from a manually controlled external signal generator. (Authorized chlorinator repair personnel carry such a device as part of their tool kits.)
3. Check buffer additive system to see if pH of sample going through the cell is maintained at 5 of less.
4. Check electrode bombardment system and see that electrodes are clean, particularly the noble metal electrode (Pt. or Au.). Do not disturb the copper electrode unless it is fouled with grease.
5. If residual analyzer is being used to measure total residual, check to see if sufficient potassium iodide is being added for the amount of residual being measured.
6. Reconnect cell output leads and make a zero, span and temperature check by following the manufacturer's procedure for a routine calibration.

Corrective Measures

1. Recorder-controller devices are equipped with a timer to interrupt the signal to the control device of the chlorinator. An oscillating residual may be controlled by shortening the "on time" of this signal so that the chlorinator does not over correct.

2. If the loop time is found to be in excess of 5 minutes, satisfactory operation will not be achieved until the loop time is brought down to 5 minutes or less. This can be accomplished by moving the injector closer to the point of application, increasing the velocity in the sample line to the analyzer cell, by moving the cell closer to the sample point, or by moving the sample point closer to the point of application.

3. If the line on the chart indicates proper operation when subjected to a simulated signal, this signifies that the equipment between the cell and the readout of the pen is satisfactory. The erratic or poor line can either be caused by poor mixing of chlorine at the point of application or faulty operation of the cell. Poor mixing can be verified by setting the chlorine feed rate for a constant dosage (proportional to flow) and analyzing a great many grab samples over a ten minute period as quickly as possible. A poor mix will show rapid wide swings of the recorder pen. Consider mixing the point of application and/or install some type of mixing device to cause turbulence at the point of application.

4. If poor mixing is not the cause, and if the electrodes are clean, and if the pH and Kl additive system is normal, then the difficulty must be in the cell and it should be replaced.

5. If when the simulated signal is applied to the recorder mechanism and the recording system does not respond properly, the difficulty lies in the electrical components of the recorder mechanism. Authorized service personnel should be summoned to correct the difficulty.

V. DISINFECTION - Chlorination

Problem

CHLORINATION SYSTEM CONSISTS OF EITHER COMPOUND-LOOP CONTROL OR DIRECT RESIDUAL CONTROL AND SYSTEM DOES NOT APPEAR TO BE CONTROLLING PROPERLY.

Indicators

1. Chlorine residual line on analyzer chart appears normal but does not track close enough to set point.

Monitoring, Analysis and/or Inspection

1. If the chlorine residual analyzer is operating properly, check the chlorinator system to see that it is functioning properly over its entire range of feed rate. Check to see if the chlorination system is feeding enough chlorine to satisfy the maximum demand; also check to see if the rotameter tube range is sized so that incremental corrections in feed rate by the residual controller are not too large. These two factors would cause wide swings in the chart line, or not allow the chlorine applied to ever actually "catch up" with the set point.

Corrective Measures

1. If the chlorination system will not feed enough chlorine, consult the corrective measures described previously under the problem of chlorination control equipment unable to feed enough chlorine.
2. If the chlorinator rotameter tube range gives too large or too small an incremental change, replace with a proper range of feed rate.

V. DISINFECTION - Chlorination

Problem

COLIFORM COUNT DOES NOT MEET THE REQUIRED DISINFECTION STANDARDS SET BY REGULATORY AGENCIES.

Indicators

1. Routine analysis of effluent or receiving waters shows MPN coliform organism to be in excess of that required by regulatory authorities.

Monitoring, Analysis and/or Inspection

1. Check capacity of chlorination equipment as follows: For primary effluent chlorinator capacity should be from 175 to 200 lb per MG. For secondary effluent 100 to 125 lb per MG and for tertiary effluent 75 to 100 lb per MG unless nitrogen removal is required. For the latter or for those plants requiring free residual chlorine, equipment capacity must be 10 mg/l of chlorine for each mg/l ammonia nitrogen in the effluent.
2. All chlorination equipment used for disinfection of wastewater effluent should have at the very least control proportional to the effluent flow. The capacity of the chlorinator should also be based on the maximum reading of the flow meter.
3. Continuously record the residual in the effluent with an amperometric type chlorine residual analyzer.
4. Check for short circuiting in contact chamber.

Corrective Measures

1. Chlorination equipment should be brought up to optimum capacity requirements. The necessary equipment should be installed to provide flow proportional control. In plants where only an influent meter exists, it may be required to install an effluent meter. After the proper primary meter is installed then the chlorinator can be modified by adding a chlorine orifice positioner to be operated either electrically or pneumatically from the primary meter.
2. A chlorine residual analyzer should be installed to properly monitor the chlorine control system. Using this apparatus to automatically control the chlorine dosage is optional; however, experience shows that the change in chlorine demand of most domestic wastewaters is significant enough to warrant the small added expense to accomplish automatic dosage control.
3. Install additional baffling in contact chamber.
4. If needed, install a mixing device in contact chamber.

V. DISINFECTION - Chlorination

Problem

COLIFORM COUNT DOES NOT MEET THE REQUIRED STANDARDS FOR DISINFECTION.

Indicators

1. Routine analysis of effluent or receiving waters shows MPN of coliform organisms to be in excess of the required standards.

Monitoring, Analysis and/or Inspection

1. Check to see if chlorine capacity is adequate, control system is functioning properly and effluent is being monitored with a continuous chlorine residual analyzer.
2. Check the chlorine contact time at low flow, average flow and maximum flow to determine the optimum residence time of the process. With this as a basis analyze five replicate samples for each hour around the clock on Monday, Wednesday, Friday and Sunday for coliform MPN after the following treatment: samples are to be taken from the effluent prior to point of application of chlorine and dosed in the laboratory with the same amount of chlorine as that applied by the chlorination equipment. The chlorine for this procedure should be taken from the plant chlorine solution line, standardized according to Standard Methods and added to one liter replicate sample of effluent. Upon addition the chlorine solution should be rapidly and thoroughly mixed, then allowed to stand for the amount of time determined previously at the optimum residence time. At the expiration of the residence time one portion of the samples should then be analyzed for chlorine residual using the iodometric back titration procedure while another portion should be dechlorinated and analyzed for coliform MPN in accordance with Standard Methods.
3. If the resulting coliform MPN from the above analysis is satisfactory, it is then reasonable to assume that the mixing at the point of application is at fault, because stirring chlorine in a batch process described above results in ideal chemical mixing.
4. Check for solids buildup in contact chamber.

Corrective Measures

1. If the difficulty is too low a residual raise feed rate and increase contact time if possible.
2. If poor mixing is the problem install a mixing device of high turbulence such as exists in an hydraulic jump or a combination of turbulent flow and mechanical mixer.
3. Clean contact chamber to reduce solids buildup.

V. DISINFECTION - Chlorination

Problem	PLANT EFFLUENT DOES NOT MEET TOXICITY REQUIREMENTS BECAUSE CHLORINE RESIDUAL TO ACHIEVE PROPER DISINFECTION IS AT TOO HIGH A LEVEL.
Indicators	1. Toxicity level is too high as determined by present bio-assay procedures.
Monitoring, Analysis and/or Inspection	1. Chlorine residual as determined by iodometric method using back titration method is deemed toxic to fish and other aquatic life in the receiving waters.
Corrective Measures	1. Install a dechlorination facility to operate in conjunction with the chlorination system.

VI. METERING

Problem PLANT METER UNRELIABLE

Indicators

1. Drop or sharp increase in totalized dry weather flow
2. Overly uniform flow chart

Monitoring, Analysis and/or Inspection

1. If meter operates on a float, check float well for obstructions.
2. If meter operates on bubbler, check bubbler tube for damage. Also check air pressure gage to see that meter is getting proper air flow.
3. Bypass measuring weir or flume if possible and check to see if meter zeros.
4. Check height of flow over weir or in flume at different time intervals and, using the weir or flume characteristics formulas, calculate flow and compare with flow meter data.
5. Compare water surface elevation immediately behind weir or flume with elevation of water in float or bubbler well.
6. Ascertain the fact that none of the plant's process return flows (centrate, supernant, waste activated sludge, etc.) are discharged upstream from the meter.
7. Install a portable flow meter in the weir or flume and compare results with plant flow.
8. If metered flow discharges into a wet well or other chamber which has a known volume and outflow can be shut off, record time of measured rise in chamber and calculate inflow rate. Compare calculated data with meter data.

9. If wastewater treated at the plant is supplied by one or more utilities and the total amount of water used is metered, compare area water consumption with plant flow. During fall or early winter months, water consumed is approximately 10% more than wastewater discharged.

10. Check magnetic flow meter cores for grease build-up or restrictions.

Corrective Measures

1. Keep all floats and bubbler wells clean and free of grease by periodic maintenance.

2. Differences between inside and outside or bubbler well water surface elevations are due to extreme velocities in the immediate area of these wells. If possible, move wells to a more quiescent area behind the weir or flume.

3. Clean all foreign matter off weir plates.

4. If problem appears to be in the meter, recording or telemetering equipment, a qualified technician should be called in to repair and calibrate the metering equipment.

VII. SOLIDS HANDLING - Sludge Thickeners

Problem ODOR FROM THICKENER

Indicators

1. Odors of hydrogen sulfide origin
2. Floating or gaseous sludge in thickener
3. Corrosion of thickener concrete structure and metal work

Monitoring, Analysis and/or Inspection

1. Run total and dissolved sulfide test of thickener effluent.
2. Check pumping rate and frequency of pumping raw sludge from thickener.
3. Run total solids test on raw sludge pumped.
4. Dewater thickener and check operation of a scrapper and/or stirrer arms and sludge removal equipment.
5. Determine sludge blanket depth.

Corrective Measures

1. Adjust pumping rate to remove solids at a frequent rate and at not less than 3% total solids.
2. Repair or replace all damaged sludge collector mechanisms.
3. Cover thickener and exhaust gases to an odor control scrubber.

Problem THICKENER CONTENTS DO NOT SETTLE

Indicators

1. Floating sludge on thickener surface
2. Floc in thickener effluent
3. Increased loadings on primary sedimentation tanks and secondary treatment process
4. Excessive sludge solids in the overflow
5. Poor concentration of underflow.

Monitoring, Analysis and/or Inspection

1. Run total solids on thickener effluent.
2. Run total solids in raw sludge withdrawn from thickener.
3. Run total solids of all thickener inflows and compare to thickener design capacity.
4. Run 30 minute settleability test of waste activated sludge inflow to thickener.

Corrective Measures

1. If thickener effluent contains high solids and the raw sludge withdrawn low solids, dose thickener with polymers or other coagulants.
2. If solids loading exceeds thickener design capacity, partially bypass thickener, if possible, by pumping raw sludge from the primary sedimentation tanks directly to the point of disposal, digester, or incinerator.
3. If waste activated sludge pumped to thickener does not readily settle, re-aerate or treat with coagulants.

VII. SOLIDS HANDLING - Sludge Thickeners

Problem

SLUDGE PUMPED FROM THICKENER HAS LOW SOLIDS CONCENTRATION

Indicators

1. Thin or watery sludge discharged to point of disposal

Monitoring, Analysis and/or Inspection

1. Run total solids of raw sludge pumped from thickener.
2. Check pumping cycle and rate of pumping raw sludge from thickener.
3. Check rate of inflow to thickener.
4. Run total solids of thickener inflow.
5. Determine depth of the sludge blanket.

Corrective Measures

1. Adjust pumping rates and cycles, preferably with timers, and remove raw sludge from thickener at a density not less than 3% total solids.
2. Adjust thickener inflows to apply total solids to thickener of not less than 2%.
3. In gravity thickness adjust pumping cycles to maintain 3 to 4 ft sludge blanket.

VII. SOLIDS HANDLING - Sludge Digestion (Anaerobic)

Problem SCUM BLANKET IN TANK

Indicators

1. Decrease in digester gas production
2. Crust visible through sight glasses in digester roof
3. Unable to supernate from upper level of digester

Monitoring, Analysis and/or Inspection

1. Core blanket through digester thief holes to determine thickness.
2. Check digester temperature.
3. Check daily digester gas production.
4. Determine gallons of scum pumped to digester daily.

Corrective Measures

1. If possible, recirculate digested sludge from bottom of digester to top of scum blanket.
2. If digester has a gas mixing system, run system continuously while increasing digester temperature to not more than 105°F with the incremental increases not exceeding 1°F per day.
3. If digester has mechanical mixers with draft tubes, degassify digester, break up scum with a high pressure water jet and direct to draft tubes.
4. Clean digester and find alternate means of scum disposal.
5. If digester has gas mixer system, place temporary gas diffusers in thief holes and pipe compressed digester gas to them.

VII. SOLIDS HANDLING - Sludge Digestion (Anaerobic)

Problem NO DIGESTER GAS PRODUCTION

Indicators

1. Gas produced has septic odor
2. Gas produced does not ignite
3. Increase in digester volatile acids
4. Increase in volatile acid/alkalinity ratio

Monitoring, Analysis and/or Inspection

1. Determing digester volatile acid, alkalinity, and pH of digested sludge together with trend of volatile acid/alkalinity ratio.
2. Check gas meter and piping for restrictions.
3. Monitor volume of raw sludge pumped to digester daily.
4. Determine total solids, volatile solids, and pH of raw sludge pumped to digester.
5. Check digester temperature.
6. Sound digester to determine depth of scum blanket and grit residue on bottom.
7. Calculate volatile matter reduction in digester.
8. Check for toxic material in the digester.

Corrective Measures

1. If volatile acid to alkalinity ratio is greater than 0.2 and pH below 6.5 add lime to digester to decrease volatile acid/alkalinity ratio and increase pH.
2. Do not feed digester raw sludge in low pH ranges (less than 7.0).
3. If volatile reduction in digester is less than 50% decrease or discontinue feeding digester until pH rises.
4. Do not feed digester raw sludge with average volatile solids less than 75%.
5. If possible transfer digested sludge with a volatile acid/alkalinity ratio of 0.2 from another digester to affected digester.
6. If scum blanket and/or grit deposits comprise more than 50% of the effective volume of the digester, clean the tank.
7. Keep digester temperature at $98^{o}F$.
8. Clean all restrictions in gas lines and/or meters.
9. If toxic material has killed digester, clean digester and determine source of toxicity to prevent recurrence.

Problem

INCREASE IN VOLATILE ACID/ALKALINITY RATIO IN DIGESTER

Indicators

1. Drop in digester gas production
2. Hydrogen sulfide odor from digester supernatant

Monitoring, Analysis and/or Inspection

1. Determine volatile acid, alkalinity and pH of digested sludge at least twice daily.
2. Check digester temperature.
3. Check pH of raw sludge pumped to digester.
4. Check mixing in digester.

Corrective Measures

1. If digester pH is below 6.5, add lime to digester.
2. If volatile acid/alkalinity ratio is greater than 0.4 decrease or discontinue feeding digester and add lime.
3. Do not feed digester raw sludges with pHs lower than 6.8.
4. Do not let digester temperatures drop below $90^{o}F$.
5. If possible, transfer sludge with low volatile acid/alkalinity ratio content from another digester to affected digester.
6. Keep contents of digester well mixed.
7. Decrease sludge withdrawal rates from digester.

Problem FOAM IN DIGESTER

Indicators

1. Foam discharged from upper level supernatant lines
2. Froth visible through sight glasses in digester roof

Monitoring, Analysis and/or Inspection

1. Determine total and volatile solids of sludge being pumped to digester and volume pumped.
2. Determine pH of digester contents.
3. Check digester temperature daily.
4. Monitor withdrawal rate of sludge from digester.
5. Ascertain depth and/or thicknesses of grit deposits and/or scum layers.
6. Check digester mixing program and effectiveness of mixing equipment.

Corrective Measures

1. Maintain digester pH between 6.8 and 7.2 and volatile acid/alkalinity ratio below 0.2 by adding lime.
2. Reduce or discontinue pumping raw sludge to digester.
3. Maintain digester temperature constant and at least at 95°F.
4. Attempt to thoroughly mix digester by recirculation or by available digester mixing equipment.
5. Break up scum layers or, if not possible, clean digester.
6. If possible, add digested sludge from a healthy digester.

VII. SOLIDS HANDLING - Sludge Digestion (Anaerobic)

Problem LOW REDUCTION OF VOLATILE SOLIDS IN DIGESTER

Indicators

1. Volatile reduction calculates to less than 50%

Monitoring, Analysis and/or Inspection

1. Determine total solids of digested sludge and/or raw sludge being pumped to digester.
2. Monitor solids loading to digester daily.
3. Monitor solids withdrawal from digester.
4. Check total solids in digester supernatant.
5. Ascertain depths and/or thickness of grit deposits and/or scum layers.
6. Determine volatile acid/alkalinity ratio and pH of digested sludge.
7. Monitor digester gas production.

Corrective Measures

1. If total or volatile solids daily loading of digester exceeds design loading, reduce the amount of sludge pumped to the digester daily.
2. Keep digester temperature above $95^{\circ}F$.
3. Raw sludge pumped to digester should contain more than 50% volatile solids.
4. Recirculate and mix digester.
5. Prolong periods of withdrawing digested sludge until volatile reduction is above 50%.
6. Lower volatile acid/alkalinity ratio and raise pH above 6.5 by adding lime to digester.
7. If supernatant contains high solids content, let digester settle.

VII. SOLIDS HANDLING - Sludge Digestion (Anaerobic)

Problem HIGH PERCENT SOLIDS IN DIGESTER SUPERNATANT

Indicators

1. Supernatant very dark and thick
2. If supernatant is circulated to plant headworks, primary and/or secondary treatment processes efficiency drops severely.

Monitoring, Analysis and/or Inspection

1. Determine total solids of digester supernatant while supernating from different levels in the digester.
2. Determine total solids of digested sludge.
3. Monitor amount of raw sludge, activated sludge, and scum pumped to the digester daily.
4. Check pH of digester supernatant.
5. Determine length of time of digester mixing.

Corrective Measures

1. If supernatant contains more than 1% solids, do not mix digester and feed alternate digester if possible.
2. Supernate from digester level which gives the least solids in the supernatant.
3. Supernate from one digester into another if possible.

VII. SOLIDS HANDLING - Centrifuging

Problem LOW SOLIDS RECOVERING RATE

Indicators

1. Centrifuge efficiency falls below 60%
2. Solids in centrate exceed 3%.
3. Centrate very dark in color.
4. If centrate is recirculated to the plant headworks, the efficiency of primary and secondary treatment processes are directly affected.
5. Cake appears thick and quite wet.

Monitoring, Analysis and/or Inspection

1. Calculate centrifuge efficiency.
2. Monitor sludge feed rate to centrifuge and percent solids in sludge.
3. Monitor coagulant, if any, feed rate to centrifuge.
4. Check centrifuge for mechanical wear.
5. Check pool depth.

Corrective Measures

1. Decrease sludge feed rate to centrifuge.
2. Increase chemical coagulant dosage, if any.
3. Repair or replace all worn centrifuge parts.
4. Increase pool volume and bowl speed.
5. Reduce conveyor speed.

VII. SOLIDS HANDLING - Vacuum Filters

Problem LOW SOLIDS RECOVERY

Indicator

1. High solids in filtrate
2. Poor clarity filtrate

Monitoring, Analysis and/or Inspection

1. Calculate filter efficiency.
2. Monitor coagulant, if any, feed.
3. Check filter mesh for blindings or coarseness.

Corrective Measures

1. Increase chemical coagulant feed rate.
2. Clean filter media.
3. Install fine mesh filter media.
4. Check sludge washing (elutriation) process.
5. Check filter drum speed and operation cycle.
6. Change types of coagulants being used.

Problem: ABNORMALLY HIGH TEMPERATURE IN FURNACE

Indicators

1. Temperature indicator exceeds limit of maximum operating temperature.
2. High temperature alarm activated.

Monitoring, Analysis and/or Inspection

1. Check rate of fuel consumption to determine if excessive.
2. Check to determine if fuel feed is off and temperature is still rising. Greasy solids may be present.
3. Check temperature indicator to see if it reads all the way up on the scale.

Corrective Measures

1. Decrease fuel feed rate, if excessive, in relation to sludge feed rate.
2. If temperature rises without supplementary fuel feed, greasy solids may be present in sludge. (This occurs infrequently when 100% primary sludge is incinerated.) To lower temperature, raise air feed rate while holding sludge feed rate constant. If air feed rate is at maximum, reduce sludge feed rate slightly.
3. If temperature indicator is all the way up the scale, this is an indication that the termocouple well is burned out. Replace thermocouple with spare unit, repair or replace thermowell with spare.

VII. SOLIDS HANDLING - Incineration

Problem ABNORMALLY LOW TEMPERATURE IN FURNACE

Indicators

1. Temperature indicator shows low on scale.

Monitoring, Analysis and/or Inspection

1. Check calorific value of sludge to determine if it is decreasing.
2. Check moisture content of sludge to determine if it is increasing.
3. Determine level of excess oxygen in stack.

Corrective Measures

1. If calorific value of sludge is low, or if sludge moisture content is high, increase the supplementary fuel feed rate.
2. If excess oxygen is abnormally high in stack exhaust, reduce the air feed rate slightly or increase sludge feed rate.

VII. SOLIDS HANDLING - Incineration

Problem HIGH OXYGEN LEVEL IN FURNACE STACK EXHAUST

Indicators

1. Oxygen analyzer (recorder chart) indicates excessive oxygen in stack exhaust

Monitoring, Analysis and/or Inspection

1. Determine total and volatile solids of sludge fed to furnace.
2. Check to determine if sludge is being fed to incinerator.

Corrective Measures

1. If sludge being fed to furnace is low in solids, increase the speed of sludge pump which feeds centrifuge. If the air feed rate is low and the sludge rate at a maximum and the exhaust oxygen is still high, shut down. The sludge supply to the furnace is inadequate.
2. If sludge is not being fed to incinerator, check for blockage of sludge in feed chute and check sludge feed pump stator. Unplug chute or repair stator if not in good condition.

VII. SOLIDS HANDLING - Incineration

Problem	LOW OXYGEN LEVEL IN FURNACE STACK EXHAUST
Indicators	1. Oxygen analyzer (recorder chart) indicates low oxygen in stack exhaust.
Monitoring, Analysis and/or Inspection	1. Check volatile content of sludge fed to furnace to determine if increasing. 2. Check sludge for grease content to determine if increasing. 3. Check to determine if air flow to furnace is restricted.
Corrective Measures	1. If the volatile content of the sludge is increasing or if the grease content of the sludge is increasing, increase the air feed rate. If the air feed rate is at maximum decrease sludge feed rate. 2. Remove any restrictions or blockages in air conduits.

VII. SOLIDS HANDLING - Sludge Lagooning

Problem

EXCESSIVE SOLIDS CARRIED OVER FROM LAGOON SUPERNATANT TO PLANT INFLUENT

Indicators

1. Dark supernatant discharged from sludge lagoons
2. Solids removal efficiency of plant treatment processes is lowered.

Monitoring, Analysis and/or Inspection

1. Determine total and suspended solids of lagoon supernatant.
2. Measure depth of sludge in lagoons.
3. Check for broken dikes between lagoons.
4. Check rate and volume of application of digested sludge to lagoons.
5. Determine total solids of sludge being applied to lagoons.

Corrective Measures

1. Reduce volume of sludge applied to lagoons thereby reducing depth of sludge in lagoon.
2. Repair all broken dikes between lagoons.
3. Delay release from lagoons of supernatant with heavy solids content until sludge is allowed to settle.

VII. SOLIDS HANDLING - Sludge Lagooning

Problem ODORS FROM SLUDGE LAGOONS

Indicators

1. Obnoxious odors from sludge lagoons.

Monitoring, Analysis and/or Inspection

1. Determine volatile acid/alkalinity ratio and pH of digested sludge being applied to lagoons.
2. Determine total and dissolved sulfide of lagoon supernatant.

Corrective Measures

1. If volatile acid/alkalinity and pH tests indicate a sour digester, attempt to correct problem at source.
2. Apply lime to surface of lagoon.
3. Install peripheral odor control system.
4. Flood lagoon with heavy chlorinated water.

APPENDIX A

EXCERPTS FROM EPA

COMPLIANCE EVALUATION INSPECTION MANUAL

April, 1978

Ontario Ministry of the Environment
Training and Certification Section
Pollution Control Branch

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EXERPTS FROM EPS COMPLIANCE EVALUATION INSPECTION MANUAL

INTRODUCTION

This manual is a guide for the professional field staff in carrying out their responsibilities in field surveillance, facility inspection and enforcement activities. It is not intended to cover every possible situation confronting an active, dynamic inspection staff. It should enable professional field personnel to perform in an effective, efficient and knowledgeable manner.

SECTION I

ADMINISTRATION

1 A WORK ETHICS

1. Professional Stature

Inspectors are expected to perform their duties in a professional and responsible manner.

Inspectors shall:

(a) Develop and report the facts of an investigation completely, accurately and objectively.

(b) Avoid, in the course of an investigation, any act or failure to act which could be considered to have been motivated by reason of personal or private gain.

(c) Make a continuing effort to improve their professional knowledge and technical skill in the investigation field.

2. Conflicts of Interest

A conflict of interest may exist whenever an employee has a personal or private interest in a matter which is related to his official duties and responsibilities. It is important to avoid even the appearance of a conflict of interest because the appearance of a conflict damages the integrity of the agency and its employees in the eyes of the public. All employees must, therefore, be constantly aware of situations which are, or give the appearance of conflicts of interest when dealing with others in or outside of the government.

3. Attire

Good public relations and common sense require that you

dress appropriately for the activity in which you are engaged. Consult your supervisor for regional policy relative to proper attire and be guided accordingly.

4. Industry and Public Relations

It is important that cooperation be obtained and good working relations established when working with the permittees and the public. This can best be accomplished by using diplomacy, tact, and persuasion. Even a hostile person should be treated with courtesy and respect. Inspectors should not speak of any person, other regulatory agency, manufacturer or industrial product in a derogatory manner. All information acquired in the course of an inspector's duties is for official use only.

5. Media Contacts

Inspectors should cooperate with representatives of the press, other communications media, and interested groups. Information concerning the Agency's responsibility for inspections and monitoring activities can be given, but questions concerning investigations of alleged violations and water enforcement policy should be referred to the District Officer.

1 B DIARIES AND FIELD NOTES

1. Responsibility

Each inspector will maintain a legible daily dairy containing an accurate and inclusive documentation of

inspection activity. Since the diary will form the basis for later written reports, it must contain only facts and observations. Language will be objective, factual and free of personal feelings or other terminology which might prove inappropriate.

2. Entries

The government's case in a formal hearing or criminal prosecution often hinges on the evidence gathered by the inspector. Vigorous regional enforcement efforts have increased the probability of inspectors being called upon to testify. Therefore it is imperative that each inspector keep detailed records of inspections, investigations, photographs taken, etc. Field notes and observations should be maintained in a bound, consecutively numbered notebook. This data will serve as an aid in giving testimony.

3. Disposition of Diaries

The diary is a part of the EPA's regional files and should not be considered the inspector's personal record.

SECTION II

PREPARATION FOR INSPECTION

II A OBJECTIVES

The primary objectives of preparation for inspection are:

1. To obtain and review all Agency information essential in conducting an effective inspection.

2. To permit completion of the scheduled number of inspections in a timely manner.

3. To minimize inconvenience to operations personnel by not requiring them either to explain or produce information which is already in the hands of the regulatory agency.

II B INSPECTOR'S RESPONSIBILITY

Inspectors are responsible for:

1. Knowledge of permit conditions, effluent limitations, monitoring requirements, etc.

2. Knowledge of applicable policies and procedures.

3. Short-range inspection scheduling.

4. Adequate pre-inspection planning.

5. Completion of follow-up procedures.

6. Adequate records maintenance.

II C PRE-INSPECTION TECHNIQUES

To achieve these objectives, several steps should be taken:

Section II: Preparation for Inspection

1. Review files consisting of: pertinent portions of permits and other related documents, prior inspection reports, the operating authorities self-monitoring reports, and other reporting data or more specifically:

   (a) A sketch or a copy of a topographical map showing the waste facility location and/or its effluent discharge point. Overflow and bypass discharge points should also be localed.

   (b) Names, titles, locations and phone numbers of the responsible persons (operators, municipal or industrial officials) involved with the water pollution control programs.

   (c) A flow chart or summary of the present and planned treatment and/or abatement facilities (If appropriate, include industrial production processes).

   (d) Inspection reports from previous inspections. Particularly the most recent Report.

   (e) Any other recent correspondence and/or regulatory action, noting the status of requested actions and/or compliance with enforcement actions.

   (f) Previous studies, consultant's reports and laboratory procedures describing non-routine analyses.

2. Significant Industrial Wastes Inputs

   Major industrial waste contributers should be

researched where they have impact on the plant or the receiving stream near the STP outfall. The review data should also include a plot plan of industry facilities showing (when applicable):

(a) Sources of raw water supply (intakes, wells, etc).

(b) Water supply and waste treatment facilities.

(c) Drainage and wastewater collection systems, including appurtenances such as catch basins.

(d) By-passes.

(e) Storage facilities, including solid waste storage facilities.

(f) Monitoring stations.

(g) Effluent discharge points and receiving waters.

(h) Manufacturing operations on a process flow sheet.

3. Inspector's Obligation

The inspectors should:

(a) Review and become familiar with the essential information in each "compliance file" before the on-site visit.

(b) Special attention must be given to the pre-inspection review of names, titles and hierarchical

relationships of the operating and/or administrative personnel for each plant. As a fundamental component of field inspection effectiveness, the cooperation of municipal (and industrial officials) involved in pollution control is essential. This cooperation is dependent upon a satisfactory professional relationship between the Ministry, industry, and municipal personnel as well as upon a deserved respect for the technical proficiency of the Ministry's inspectors.

4. Equipment Needed by the Inspector

Depending on the facilities to be inspected, equipment should consist of some or all the following items.

(a) Personal Protection

See Section VII of this Manual, Safety.

(b) Miscellaneous

(i) Camera
(ii) Pocket Calculator
(iii) Thermometer
(iv) Sample bottles
(v) Clip board (with appropriate check-list)
(vii) Level
(vii) Psychrometer
(viii) Range finder
(ix) Tape measure
(x) Compass
(xi) Stopwatch
(xii) Wind meter or Admiral Beauford Wind Scale
(xiii) Square

It should be noted that this is a minimum list of equipment which may be required by the inspector. However, it is

recognized that all the equipment may not be needed on any given inspection. Many of the items are primarily for air compliance monitoring inspections.

5. Review of Inspection Check Lists

To insure that all necessary areas of concern are reviewed during the inspection, a series of checklists have been developed for use by the inspector. Some of these checklists are contained in Exhibit "B" of this Manual. If the inspector's organization has already developed checklists that include these points (as a minimum), such checklists may be substituted. The checklist should be used as a tool for insuring a comprehensive review, but should not be used as a substitute for judgement.

SECTION III

TREATMENT FACILITY INSPECTION

III A AUTHORITY

Section 50. - (1) of the Ontario Water Resources Act states:

"Sewage works shall at all times be maintained, kept in repair and operated in such manner and with such facilities as may be directed from time to time by a Director."

In addition, the Director is empowered by Section 49. of the OWR Act to require the owner of a sewage work "to make returns" to the Director. Therefore, owners of sewage works may be required to operate their works to satisfy the Director and may be required to supply the Ministry with any information.

Also the Minister or his authorized representatives are authorized to enter into lands and Buildings in the province to make surveys and inspections as necessary (Section 20. - (1) of the OWR Act).

III B INSPECTION PROCEDURES

(a) General

To fully evaluate the overall plant operation, an inspector should have a full understanding of each treatment process, how each process fits into the overall treatment process and the "upstream" conditions that affect treatment operations. A good understanding of operating details is invaluable

to the inspector in evaluating the operating results and the extent to which the operating personnel understand how the unit operations and processes individually and collectively, perform their functions.

(b) Industrial

Because of the wide variety and the complex nature of industrial wastes, special knowledge and techniques are essential for adequate inspection of industrial facilities.

The inspector must have knowledge of:

(i) Industrial flow diagrams of raw water, production use, raw materials, additives, end products, by-products, and liquid, gaseous and solid wastes.

(ii) Water consumption, distribution, usage and the hydraulics of drainage and collection systems for process waters and industrial wastewaters.

(iii) Production processes, materials used, "dump" schedules, treatment required, treatment equipment, wastewater characteristics and methods of treatment and disposal of sludge and other treatment residuals.

On an initial facility visit, it may be advantageous to have industrial abatement staff, the plant engineer or chief operator describe the plant and its principal operating characteristics as a supplement to the

inspector's review of plans from the files. This step will help to orient you and give you an indication of how well the operating personnel understand the system.

(c) Treatment Observations

During the plant tour the inspector should be alert and inquire about:

(i) Accumulations of solids and scum in wet wells, excessive scum build-up, grease, foam or floating materials in tanks.

(ii) Surcharging of influent lines, over-flow weirs and other structures.

(iii) Obnoxious odors in wet wells, grit chambers, around aerobic and anaerobic biological units, scum removal devices and sludge handling facilities.

(iv) Vital treatment units out of service for repairs. Determine when they were taken out of service, the type of failure and when the units will be put back in service.

(v) Excessive weed and tule growths in stabilization ponds, etc. Check earthen retention walls (dikes) for breaches, leaks and maintenance.

(vi) Freezing wastewater in ammonia stripping towers and formation of excessive calcium

carbonate deposits on tower structures, fouling of fabric in microscreens with grease and solids and mechanical fouling of activated carbon columns.

(vii) Alternate discharge points, channels or other areas likely to have overflows. (Inspect to see if spills or unauthorized usage has recently occurred as a result of the operating personnel attempting to correct operational problems).

(viii) Sludge decomposing in clarifiers as indicated by gas bubbles rising to the surface or by floating sludge pads.

(ix) Any unusual equipment such as special pumps, floating aerators in diffused air systems, chemical feeders, temporary construction or structures, or any jerry-rigged systems intended to correct operational problems.

(x) Excessive suspended solids, turbidity, foam, grease, scum, color, and other microscopic particulate matter in the plant effluent and the receiving waters.

(xi) Collected screenings, slurries, sludges or other by-products of treatment. Their disposal including the runoff of wastewaters,

must be in such a manner as to prevent entry into navigable waters or their tributaries.

(xii) Adequate safeguards to prevent the discharge of untreated or inadequately treated wastes during electrical failures.

(xiii) Infiltration and inflow problems.

(d) Process Verification: Industrial

Industries frequently make production changes because of the introduction of new technology, new products, new processes, etc. Therefore, the industrial waste inspector should inquire:

(i) If a company has made any changes in production processes, raw materials, amount of finished product, water usage, waste treatment processes and other such changes. Specifically, the inspector should determine if the company has made changes that would increase the discharge of pollutants above the effluent limitations.

(e) Maintenance

Good operation and good maintenance go together. Good maintenance indicates that plant operating personnel are giving adequate emphasis to the plant's facilities and performance. Sloppy maintenance may indicate the operator's lack of concern or ability. The usual result is a number of problems, including poor operation and the discharge of excessive pollutants into the receiving water and/or atmosphere.

The inspector should inquire about the maintenance programs for:

(i) All mechanical equipment (i.e., pumps, clarifier scraper mechanism etc.)

(ii) Guard rails and safe walkways around and between tanks, pits, and major unit.

(iii) Condition of safety/reinforcing mechanisms or devices.

(iv) Proper lighting.

(v) Cleaning of areas where waste allowed to accumulate.

(vi) Protective paint on units and color coded piping systems.

III C POST INSPECTION DISCUSSION WITH MANAGEMENT

To achieve the most effective results from inspections, it is essential to have timely communication of the results to management and/or operating personnel. Failure to discuss the results can cause a loss of mutual respect. When this occurs, it is a deterrent to good inspector-operator relations and understanding. However, the inspector's discussion should be limited to specific findings of the visit.

Precautions and Guidelines

Although a discussion of the inspection results if important, certain precautions are essential.

The inspector must:

(a) Realize that it is an unacceptable practice to

recommend a particular consultant or consulting firm even if asked to do so. However, it is not unethical to inform the operator or agent, to contact a professional society for advice concerning this matter or to supply a list of consultants who have done similar work for other plant owners.

(b) Make no attempt to substitute your own judgement for that of plant operating personnel regarding details of operation.

SECTION IV

RECORDS AND REPORTS INSPECTION

IV A PROCEDURES

Conducting the Inspection of Plant Records

1. Cursory Inspections of Plant Records

On an initial visit to a treatment plant, the inspector should discuss the record keeping and reporting requirements with management. This type of inspection should use the checklist provided in Appendix "B" and be limited to the verification of:

(a) The maintenance of sampling and analysis data.

(b) The maintenance of daily operating logs. These are important and they should be bound in notebooks to prevent their alteration or destruction. Information on the daily log sheet for a municipal plant should include:

(i) A summary of all lab tests run.

(ii) A format for calculating BOD and equivalent tests.

(iii) Weather conditions (temperature, precipitation, etc.)

(iv) Chemicals used such as pounds of chlorine used per day.

(c) The maintenance of management generated records, such as average monthly operating records and annual reports, emergency conditions, such as power failures, by-pass and chlorine failure reports. These records should be requested during the inspection to facilitate the inspector's review.

(d) The maintenance of pretreatment records, including industrial waste ordinance (or equivalent documents), inventory of industrial waste contributors including compliance/noncompliance records and user charge information.

(e) The maintenance of laboratory records including all original strip charts from continuous monitoring instrumentation and calibration and maintenance records.

(f) The maintenance of physical plant records at the plant for reference. These include:

(i) O&M Plant Manual. (Municipal only)
(ii) "As built" engineering drawings.
(iii) Copy of construction specifications.
(iv) Equipment supplier manual.
(v) Data cards on all equipment.

(g) Adequate retention of records for a minimum period (three years).

2. In-depth Inspections of Plant Records

This inspection may be conducted primarily to check records and reports. For example, such an inspection may be warranted:

(a) If the self-reported data are suspected to be grossly inaccurate and the problem is believed to be with the record keeping and/or the filing.

Section IV: Records and Reports Inspection

(b) If the discharge does not meet required standards and no definite operational problem areas have been established.

(c) If the cursory inspection indicates omissions or laxity in the preparation of records.

SECTION V

SELF MONITORING PROGRAM INSPECTION

V A OBJECTIVES

The objective of this phase of the Compliance Evaluation Inspection is to:

1. Confirm the sampling and flow measurement equipment are provided and that they are being operated and maintained properly.

2. Verify that the analyses are being performed with the proper equipment and by persons who have the requisite skills.

3. Confirm that the analytical tests methods used for pollutants or parameters conform with the acceptable practices.

V B PROCEDURES

1. Conducting the Investigation

   (a) Flow Measurement: Weirs

   The inspector should confirm that flow measurement devices utilized are appropriate for the waste stream being measured. In addition, the inspector should verify that each device is free of sticks, rags and other debris and that it is properly installed. Proper installation of a weir means that:*

   (i) The device is installed exactly level.

   (ii) The weir plate is plumb and the top edge is sharp and clean.

(iii) There is free access for air to the underside of the nappe of the overflowing stream.

(iv) The channel upstream from the weir is reasonably straight, level and free from disturbing influences so that the stream assumes a quiet flow.

(v) The stilling basin is of sufficient size.

*NOTE: These criteria apply to a sharp-crested weir. However, the owner could have a broad-crested weir with a developed rating curve. The inspector should verify that the proper curve is being used.

(b) Flow Measurement: Other Devices

Other types of flow measuring devices used in municipal and industrial applications include:

(i) Parshall flume

(ii) Venturi meter

(iii) Magmeter

(iv) Palmer-Bowlus Flume

(v) Orifice Meter

It is not within the province of this Manual to discuss and describe the various flow measurement devices since those details are readily available in other publications. For such detailed information the inspector might consult the EPA Handbook For Monitoring Industrial Wastewater, the Department of Commerce/National Bureau of

Standards Publication 421, A Guide To Methods And Standards For The Measurement of Water Flow or the Department of Interior Bureau of Reclamation's Water Measurement Manual.

All flow measuring devices are subject to calibration. Therefore, the inspector should check to determine if calibration records are available, the most recent date of calibration and the flow measurement accuracy obtained. Then comparison should be made with the manufacturer's accuracy for the device. The inspector should check to see if proper and accurate rating curves or tables are being used for accurate measurement of flows.

(c) Sampling

The inspector should verify:

(i) That samples are taken at the locations prescribed.

(ii) That the sampling location specified in the permit is adequate to provide a well mixed and representative sample.

(iii) That the frequency of sampling (grab samples and sampling interval for composites) is done in accordance with proper procedures.

(iv) That grab sample devices, if used, are clean and are properly operated.

(v) That sample containers are clean and appropriate for the parameter or parameters to be analyzed.

(vi) That automatic sample collectors, if used, operate properly. In hot weather, refrigeration should be provided for certain parameters such as BOD. In winter, protection from freezing may also be necessary.

(vii) That proper chemical preservatives are used for (time) composite samples and for grab samples which are not analyzed immediately following sample collection.

(viii) That samples are received and analyzed within holding times specified in the appropriate method of analysis.

(ix) If there is more than one sampling point, determine that appropriate measures are used to prevent cross contamination between samples and that sample containers are properly identified.

(x) That all field testing equipment is routinely calibrated.

(d) Laboratory: On-Site

The inspection of on-site analysis should verify:

(i) That the specific methods of analysis used are approved for the particular parameter, or an approved alternate method.

(ii) That the laboratory has written instructions on the methodology employed.

(iii) That quality control methods such as the analysis of blank, spiked, and split samples are employed.

(iv) That the presence of known interferences in the analyzed samples is established and steps taken to remove the interferences.

(v) That laboratory personnel are familiar with the analysis being performed including:

- Procedures for cleaning equipment.
- Reagent quality control, including source of distilled water, frequency of reagent standardization, and reagent shelf life.
- Media preservation and sterilization techniques.
- Use of bench cards and/or notebooks.
- Use of available analytical instrumentation.
- Calculation of results.

(vi) That where more than one person routinely performs portions of particular analysis, the person performing a specific portion should be identified by a "sign-off" procedure.

(vii) That for analyses performed using automatic sampling and analytical instrumentation, the device(s) should be identified by manufacturer, model etc., and the

operation, calibration and procedures followed should be noted.

(viii) That the location of the laboratory equipment and/or instrumentation should be noted.

(e) Laboratory: Off-Site or Contract

For "off-site" analyses performed by a Provincial or contract laboratory, the inspector should verify the name and address of the contract laboratory.

SECTION VI

SPECIAL CONSIDERATIONS AND TECHNIQUES

VI A PROCEDURES

1. Inspector's Obligations

Inspectors shall:

(a) Report all readily observable sources of environmental pollution and occupational health and safety hazards to their immediate supervisors.

(b) Become familiar with readily observable indicators of environmental pollution and any health or safety hazards encountered when making inspections.

(c) Be aware of the basic environmental requirements in other media programs to which a specific source is subject.

(d) Be adequately trained in the use of special techniques generally employed for a particular medium program before conducting in-depth inspections. However, for cursory inspections, inspectors need not be well versed on all environmental programs but only capable of identifying potential problems

VI B COMPLAINT INVESTIGATIONS

1. General

Every public agency, is the recipient of many citizen's complaints. From a public relations standpoint, complaints should be welcomed from those the Agency is supposed to serve since this is one of several ways in which its overall surveillance activities may be improved. In any case, field surveillance personnel may

be called upon to investigate complaints that concern reports of alleged pollution, inquiries regarding discharges and requests to abate specific problems.

2. Conducting Complaint Investigations

Certain steps should be followed in handling them. The first is determine if sufficient information is available to conduct an investigation. This should include:

(a) The complainant's name, address and telephone number.

(b) Exact location of the alleged discharge or conditions the complainant made reference to.

(c) Details of the complaint.

The next step is to check at once, if possible, whatever records exist that might substantiate or disprove the complaint. If possible, the operator or agent in charge of an alleged discharge should also be present during the investigation. In some instances, it is desirable to have the complainant present during the investigation. However, circumstances will dictate whether or not this is wise.

If the complaint concerns a wastewater discharge, the same information should be reported, including the circumstances of any property damage, fish, bird or wildlife kills or injuries.

When the investigation has been completed, the discharger and complainant should be informed of the results and that each can expect a timely written response regarding the appropriate action that will be taken to correct

the problem.

VI C PHOTOGRAPHS

1. General

The inspector may wish to take photographs of:

(a) Overall view, where possible, showing arrangement, relative size and general condition of the facility.

(b) All sampling points.

(c) Major process units within the waste treatment facility.

(d) Operation and maintenance conditions.

(e) Effluent discharge points.

(f) Receiving water areas.

Photos should be keyed to the plot plan, flow diagram or location on the map. It is always desirable to obtain management's approval before taking photographs. If there are objections to the use of camera, explain in a tactful manner that the photographs will enable you to prepare a more thorough and accurate inspection report. Facility modification and/or additions and changes in effluent or receiving water conditions should be recorded as they occur with clearly identified photographs showing the date, time and signature of the photographer. For instance, such photographically identifiable changes include:

(a) Bypass discharges.

(b) Floating solids.

(c) Excessive foaming.

(d) Iridescent sheens and/or oil films.

(e) Turbidity and discoloration.

(f) Problems at solid waste disposal sites.

(g) Air pollution plumes.

(h) Unauthorized discharge points.

In addition to aiding in the explanation of problem conditions to experienced and/or office personnel, properly documented photograpsh of waste discharge and attendant effects will materially aid in follow-up procedures.

2. Identification Requirements

The inspection report accompanying enforcement-oriented photography must to the extent practicable carefully note the:

(a) Subject

(b) Location

(c) Points of reference

(d) Photographer's name

(e) Date and time

(f) Type of camera used

(g) Lighting conditions encountered

(h) Focal length of lenses

(i) Type and speed of film

(j) Name of any witnesses

This photographic information is essential to insure court admissibility.

SECTION VII

SAFETY

VII A GENERAL

The inspection of wastewater and other environmental pollution control facilities always poses a certain degree of hazard. The objective of this section is to assure the safety of inspection and operating personnel by the use of proper safety equipment and by the execution of safe practices.

Inspector's Responsibility

It is the responsibility of each inspector to:

(1) Be thoroughly familiar with all safety guidance and practices.

(2) Maintain safety equipment in good condition and in proper working order.

(3) Use safety equipment in accordance with guidance received, and labeling instructions or as dictated by common sense.

(4) Guard against body infections by periodically obtaining typhoid and tetanus innoculations.

VII B SAFETY EQUIPMENT

1. Personal Safety Gear

When performing their inspection duties, inspection personnel should properly use the following safety equipment:

(a) Hard hats.

(b) Rubber-soled, non-skid, metal-toed shoes.

(c) Safety glasses (prescription if required), gog-

les and face shield.

(d) Gloves: liquid-proof, natural or synthetic rubber, or throw-away plastic.

(e) Non-skid, metal toed, rubber boots.

(f) Ear protectors.

(g) Breathing mask or respirator.

2. Safety Equipment

The following safety equipment should be in each inspector's car for use when needed:

(a) First aid kit.

(b) Fire extinguisher.

(c) Soap, waterless hand cleaner, and towels.

VII C SAFETY PRECAUTIONS

Inspection and Operating Personnel

1. Authority

Safety is considered to be an integral component of such assurance since unsafe conditions and practices adversely affect the operation and maintenance of wastewater facilities.

2. Inspector's Obligations

The inspector should be on-guard to protect himself from injury which may result from unsafe conditions or practices at the wastewater treatment facility. As a guide in this area all field inspectors should read Safety in Wastewater Works published by the Water Pollution Control Federation. This publication discusses safety precautions necessary for the:

(a) Prevention of physical injuries;

(b) Prevention of body infections;

(c) Prevention of asphyxiation due to lack of oxygen or presence of noxious gases;

(d) Proper operation of safety equipment; and

(e) Rescue of injured employees.

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REPORT WRITING: THE LANGUAGE AND STRUCTURE OF REPORTS

1. Definition of a report

A report may be defined as "a formal or official presentation of facts or of the record of something, as an investigation".

2. The nature of a report

There are two main characteristics of a report.

(a) It is capable of verification. For example, if you report to your landlord that the ceiling is leaking, he may verify it by going to your room and seeing the drops of water himself.

(b) It excludes, as far as possible, inferences and judgments - that is, it features observations.

You should not include such phrases as "poor condition", "bad location", "belligerent operator". These are not observations, but judgments. If you were to give observations instead of judgments, you would say something like "the top five courses of brick are breaking away" instead of "poor condition"; "the chlorinator is located in the high lift pump room", instead of, "bad location"; and "the operator asked me to get off his property when I asked him if I might discuss the chlorinator location with him "instead of belligerent operator".

Two main problems arise when judgments are inserted in reports as observations:

(a) The person who receives the report may have a completely different interpretation of the judgment from the person who made it. The chance of misunderstanding observations is likely to be much less.

(b) Once a judgment is made, subsequent observations tend to support that judgment, and the reporter tends to exclude those observations which do not support the judgment.

As a general rule, then, it may be useful to record judgments as comments rather than observations.

2. The nature of observations

A simplification of Einstein's Theory of Relativity states that "every observation is related to the observer and to that which is observed". Thus, every observer is a part of what he observes; and it follows that every observation is to some extent subjective. There is no such thing, then, as an "objective observation".

No two people will see the same facts the same way. People on witness stands, who have no reason to deceive, will disagree strongly on what really happened. We can never know "what really happened"; all we can know is what happened in relationship to ourselves.

Ernest Hemingway, the great American fiction writer, once wrote that "facts can be observed badly". Hayakawa, the American general semanticist, has shown how different observations can be made from the same set of facts, with a consequent range effect on listeners or readers.

The form of reports

The form of a report is usually determined by a simple question: what is the reader, or receiver, looking for? What does he want in the report? Every person who receives reports has the responsibility to tell the person who writes them exactly what he (the reader) is looking for in the reports. One of two forms of report will generally be used.

(a) Narrative - sometimes called descriptive, open, free-flowing. While this type permits the creative gifts of the writer to be exercised to their fullest extent, it also often leads to wandering from the point, the inclusion of too much detail, the inclusion of irrelevant detail or irrelevant points, etc. See handout, "Duties of a C.I.A. Field Manager".

(b) Structured - sometimes called slotted (because the responses have to be put into "slots".

This type does little for the writer with a creative impulse, but it does tend to same time, it elicits responses that the receiver is looking for and excludes those in which he has no interest. See handout, "Duties of a Production Fieldman".

The structured type of report used by the Former Sanitary Engineering Branch is an excellent example of this type.

Writing Weaknesses

A number of writing weaknesses seem to persist in narrative reports. Some of these we will not look at in a handout entitled (appropriately) "Some Illustrations of Writing Weaknesses".

Government Report Writing

Terms like "gobbledigook" and "federalese" have often been used to describe some persons' impressions of government writing. Several years ago, an analysis was made of U.S. Government Reports. Let's look at this report on reports, which describes 10 major faults in government report writing.

Readibility

Can anything be done to make our writing more readable? Much study and research have been given to this question, with two men being particularly well known in the field: Rudolph Flesch and Robert Gunning. We have time to discuss only one: and because Gunning's method does not require a reading-difficulty scale for reference, we will discuss his method.

Gunning's method provides us with a "Fog Index" of written material - that is, it tells us how "foggy" or unreadable the material is. We must be aware that we are dealing with ease of reading and not comprehension. We know that the easier any material is to read, the easier it is to understand (other things being equal); that is, we know there is a relationship between readibility and comprehension, but we don't know what the

precise relationship is. The Fog Index can indicate for us how difficult a given piece or writing may be to read.

Before we turn to the handout that explains the index, we should note one or two things:

(1) Very few people will read voluntarily and writing whose level of difficulty is beyond that of the last formal grade of school completed - unless they have a particular interest in the subject, have maintained an active interest in educational programs, etc.

(2) Irrespective of the amount of formal education completed, very few persons voluntarily read any material which is above a Grade 12 level of difficulty.

(3) No popular magazine can survive whose reading difficulty is beyond the Grade 12 level.

Applying the Fog Index method to the handout "Duties of a C.I.A. Field Manager", we find that:

a. The 100th word in the sample is the "and" after "discussion" in line 11.

b. Sentence length is then $\frac{100}{2}$ = 50

c. Number of three-syllable words = 13
Sum 63
Multiply by constant .4

d. Fox Index or theoretical grade level = 25.2

As a rough guide, try for average sentence length of between 15 and 20 words, and no more than 10 large, unfamiliar words in the average 100 words. Thus, an average sentence length of 17 words and large-word count of 8 will yield a Fog Index of 10. This is the level of such publications as Time magazine, and most newspapers.

As an antidote to all that we have said about the Fog Index, we shall look at a comment by Pierre Berton on the method.

8. Differences between Written and Spoken Styles in Communication

Although an oral report is often simply a written report which is read aloud, there are differences between written and spoken styles that should be noted by anyone who must make both oral and written reports. The handout attempts to set out some of these differences.

9. Dictation

Many of you may dictate your reports. Dictation is a fine art, so much so that the U.S. Government has prepared a little booklet with the somewhat startling title, "Advice to Dictaters". The overriding consideration here is organization of one's thoughts before one dictates. As an example of what can happen, we may read the letter dictated by Robert Benchley.

10. References

Writing a Technical Paper - Menzel, Jones, and Boyd (Toronto: McGraw-Hill, 1961). Listed price $3.25

Language in Thought and Action (Second Edition) - S.I. Hayakawa (Toronto:

Longmans Canada
Ltd., 1964).
Listed price $3.25

The Technique of Clear Writing - Robert Gunning (Toronto: McGraw-Hill, 1952). (This book is not listed in the latest McGraw-Hill catalogue, but copies may be available in book stores featuring college texts and technical books).

Duties of a C.I.A. Field Manager

To be trained in his particular industry, with C.I.A., this means underwriting, selection of risks, claims service, working closely with Federation of Agriculture Insurance Committees, in the placing of agents in the county or counties, the follow-through in the training of these agents, arranging meetings with them to keep them up to date in all phases of our operations - this includes sales training also.

Working towards good public relations with all our sponsoring and affiliated organizations (to know their problems and assisting them when possible) and to keep informed of their meetings and subjects under discussion and to inform them of our problems and meetings.

To this end my thoughts are that all fieldmen should have a short course on salesmanship - this we endeavour to do with C.I.A. It gives them a real insight into human relations, and enables them to look at the problems of other people more realistically so that they can help solve these problems, and also teaches them that they should be conversant with the particular industry of the people they are doing business with, whether it be farmers, managers of co-operatives, credit unions, producers co-ops., etc. It also teaches how to express oneself in an intelligent manner so that any message is understandable - lack of understanding is deplorable in industry and human relations, and everyone suffers in consequence.

Duties of a Production Fieldman

Responsible to: The Production Sales Manager

Responsible for: The performance of the Sales and Service function on the wholesale level and assisting with the development of sales and service programs at the retail level, working in conjunction with the Area Supervisor in the area assigned, (feed, seed, fertilizer and grain).

Required to:

Write and encourage placing by Locals of wholesale orders for products handled by the Production Division.

Assist the retail outlets in sales and service of the products of the Production Division.

Assist with the training and motivation of retail staff in sales and service.

Perform duties of a service nature which involve instruction in the proper use and application of the products, and proper related management practices necessary to assure success in the use of the products.

Handle any problems or complaints related to the products concerned.

Promote the general teamwork effort in contributing to the success of U.C.O. programs in the field.

Do other related duties of a sales and service nature as required.

Requirements:

Agricultural graduate or the equivalent.
One - three years' related experience preferred.
Knowledge of products handled.
Interest in and aptitude for sales and service work.
Farm and rural background preferred.
Willingness to reside in the area assigned.

Some Illustrations

of Writing Weaknesses

1. Nouns that convert to verbs:

The variation in the hardness of each specimen is considerable.

The argument of the farmers is that they have to dump their grain.

2. Useless thing-is-thing statements:

One method of estimating factors is the centroid method. The centroid method for determining one factor is as follows:

The subject under discussion in this thesis is a group of islands known as the St. Clair Flats.

3. Overuse of there is, there are:

There are several features of this idea that merit comment.

4. General, or non-specific, verbs:

These attitudes have a strong influence on behaviour.

Rats have an ability to make selections of healthful food.

I have exercised much care in the selection and preparation of the illustrations.

A slight increase in the soil pH took place.

5. Strings of prepositional phrases:

Much of the work of Richter has dealt with the maintenance of the

constancy of the internal environment through the operation of behaviour regulators. (7 prepositions; 24 words).

6. Empty nouns:

Injury to the heart may be of a temporary nature.

Irrigation, mowing, and fetilization have been used with varying degrees of success.

The poor quality of the supervision and administration was the specific factor most often cited as a reason for leaving a job.

7. Active versus passive voice:

Periods for petal fall were delayed by shading.

It may be seen from Table 37 that the mean head-lengths of these fish are 8.349 and 7.811, respectively.

It is felt that a decrease of mortality and morbidity might be effected by a better understanding of the recently available pharmacological tools and the exercise of greater precision in their use. (32 words).

8. Dangling modifiers:

While whistling a tune, a car suddenly stopped in front of us.

Poking around in the ruins, a skull was uncovered.

To play tennis skillfully, the basic strokes must be learned.

At the age of two, my mother died.

9. Faulty parallelism:

The forty years since the Combines Act was passed have brought

many social and technological changes. Some of these changes are as follows:

1. From rural to highly urban and industrialized society.

2. More women than men.

3. Increased number of aged persons in the population.

4. Labor force has increased.

5. More women entering the labor force.

6. Automation has increased the number of "white collar" jobs.

7. Types of skills and abilities needed have changed.

8. More leisure time per individual.

From - The Congressional Record

Ten Major Faults in Government Report Writing

Extension of Remarks of Hon. Knute Hill
of WASHINGTON

In the House of Representatives, Tuesday, April 21, 1942

Mr. Hill of Washington. Mr. Speaker, the communication between the Government and its citizens through the reports of its agencies is one of the basic processes of democratic society. If the channels of communication bog down in verbiage, the people are not only confused but begin to lose touch with their Government. The public-relations faculty of the American University has been studying Government reports for more than 5 years under the leadership of Prof. William Dow Boutwell. The results of the study are so simple and constructive that I believe they should be made available to every person concerned with drafting reports which convey information of significance to citizens. I ask, therefore, unanimous consent to have a summmary of Prof. Boutwell's study of the 10 major faults in writing by Government officials printed in the RECORD.

1. Sentences are too long

Voted unanimously as one of the worst faults in nearly all writings analyzed. Average sentencelength in poor Government writing varies from 65 to 80 words per sentence. In exceptionally good Government writing (Report to the Nation by Office of Facts & Figures and President's Speeches) average length is from 15 to 18 words per sentence.

2. Too much hedging: too many modifications and conditional clauses and phrases.

The master writer will say, "A third of a nation all-clothed, ill-house, ill-fed". The amateur writer will write: "On the whole it may be said that on the basis of available evidence the majority of our population is probably not receiving the proper type of mutriment.###" Psychologists say that "conditional clauses cause suspension of judgment as to the outcome of the sentence, and therefore increase reading difficulty."

3. Weak, ineffective verbs.

"Point out," (indicate) or "reveal" are the weak reeds upon which many a Government sentence leans. Writers overuse parts of the verb "to be." Hundered-word sentences with "was" or "is" as the principal verb are not uncommon.

4. Too many sentences begin the same way, especially with "The".

A sentence betinning with "The" is like a day beginning with a fog. Yet, look at this:

"The present volume on expenditures for housing is one of a number of publications prepared by the Bureau of .... from data

obtained in the study of consumer purchases. The results of this study are presented in three series of reports, of which the present constitutes the third. The first series was concerned with an analysis of the distribution by income class, occupational group, family type, nativity, and home tenure, of families studies in selected communities in different parts of the country. Each volume in that series pertained to a specific geographic region. The second series comprised reports for the same regions on the size and relative importance of expenditures for the main categories of family living, with only incidental reference to the constituent items in these categories. The third series presents detailed data collected in all regions covered by the study for each of the more important of these categories."

5. The attempt to be impersonal, which forces use of passive tenses and indirect phrases.

Example: "To determine whether retail sales have been out of line with expectations based on the past relationship of retail volume to income, estimates of retail sales in the first half of each year from 1935 through 1940 have been charted against income payments for the same periods, and a line of estimate fitted to the resulting scatter."

6. Overabundance of abstract nouns.

Such nouns as "condition"; "data", "situation", development", "problem", "factor", "position", basis", "case", dominate the writing of too many Government documents. How bright and real writing becomes when picture-bearing nouns take the place of vague ones may-be-seen by this sentence:

"During the lean years when salaries and wages were low and irregular the people who drifted into the credit-union offices came around because they had dropped behind in their personal and family finances and had to eat a loan."

7. Too many prepositional phrases.

In a study of reading difficulty, investigators (Drs. Leary and Gray of Chicago University) found that prepositional phrases ("of the data", "Under the circumstances", etc.) add to reading difficulty. Yet, samples of Government writing show that many officials use at least one prepositional phrase to every 4 words. Samples from good writing contain only one prepositional phrase to every 11 words.

8. Overabundance of expletives.

"It is" and "there are" and their variants ruin the opening of many good paragraphs.

9. Use of governmentish or federalese.

"Shop words" serve a proper purpose for "shop" audiences. But many Government writers make the mistake of talking to the public in technical, office terms, for example: "The 201 reporting schedules", "the vend program", "primary forage-plant method".

The above nine faults have to do with structure of language. There is, however, even a deeper difficulty in the writing of Government

documents, which make many of them so difficult to the average reader _____. This might be described as a - - -

10. Tendency to make ideas the heroes of sentence.

People think in terms of people and things for the most part. The Government official writes in terms of ideas and phenomena only.

Hence, when a writer means: "Employers refuse to hire older workers in defence industries", he writes instead: "Refusal of employment of older workers continues." In other words, the writer has substituted "refusal", and idea of phenomenon, for "employers" -- living people.

Gunning Fog Index

1. Count words to the sentence that ends nearest a 100-word total. Divide the total no. of words in the passage by the no. of sentences. This give the average no. of words per sentence.

2. Count the no. of words of three syllables or more per 100 words. Don't count the words that (a) are capitalized, (b) are combinations of short, easy words, and (c) are verb forms made into three syllables by adding -ed or -es. This gives the percentage of hard words in the passage.

3. To get the Fog Index, total the two factors just counted and multiply by 0.4.

4. Refer to the Fog Index Table shown below.

	Fog Index	Reading Level by Grade	By Magazine
	17	College graduate	
	16	College senior	
	15	College junior	(no popular magazine this difficult)
	14	College sophomore	
Danger line	13	College freshman	
	12	High school senior	Atlantic Monthly
	11	High school junior	Harper's
	10	High school sophomore	Time
	9	High school freshman	Reader's Digest
Easy-reading range	8	Eighth grade	Ladies Home Journal
	7	Seventh grade	True Confessions
	6	Sixth grade	Comics

I have a feeling that it is this constant dilution of the English language, this frightening trend towards over-simplification, this dread of "hard" words, big sentences and big concepts that is causing the real fog. Years of conditioning by the Reader's Digest, with its simple words and simple little black and white ideas, have made it impossible for thousands of allegedly literate newspaper readers to understand the complexities of the modern world - let alone the none-too-subtle inanities of a rebel columnist.

Pierre Berton, "Fast Fast Fast Relief", Page 89

A Serious Note on Dictation -- and Benchley, Too

Here is an excerpt from Robert Benchley's delightful "From Nine to Five" -- about how not to dictate business letters.

"Personally I am not what is known as a 'snappy' dictator. It makes me nervous to have a stenographer sitting there waiting for me to say something so that she can pounce on it and tear it into hieroglyphics. I feel that, mentally, she is checking me up with other men who have dictated to her, and that I am being placed in Class 5a, along with the licensed pilots and mental defectives and the more I think of it the more incoherent I become. If exact and detailed notes were to be preserved of one of my dictated letters, mental processes, and all, they might read something like this:

"Good morning, Miss Kettle ..... Take a letter, please .. to the Nipco Drop Forge and Tool Company, Schenectady ... S-c-h-e-c-er-well, Schenectady; you know how to spell that, I guess, Miss Kettle, ha! ha! ... Nipco Drop Forge and Tool Company, Schenectady, New York .... Gentlemen--er (business of touching fingertips and looking at the ceiling meditatively) -- Your favour of the 17th inst. at hand, and in reply would state that -- er (I should have thought this letter out before beginning to dictate and decided just what it is that we desire to state in reply) -- and in reply would state that -- er .... our Mr. Mellish reports that -- er ... where is that letter from Mr. Mellish, Miss Kettle? ... The one about the casting ..... Oh, never mind, I guess I can remember what he said. ..... Let's see, where were we? Oh, yes, that our Mellish reports that he shaw the shipment ..... I mean saw the shipment ... what's the matter with me? (this girl must think that I'm a perfect fool) ... that he saw the shipment in question on the platform of the station at Miller's Falls, and that it -- er. ... ah .... oom ... (I'll have this girl asleep in her chair in a minute. I'll bet that she goes and tells the other girls that she has just taken a letter from a man with the mind of an eight-year-old boy) ..... We could, therefore, comma. ..... What's the matter? Oh, yes ... and that I, or rather it, was in good shape ..... er, cross that out please (this girl is simply wasting her time here. I could spell this out with alphabet blocks quicker and let her copy it) ..... and that it was in excellent shape at that shape--er ..... or rather, at that time ..... er ..... period. New Paragraph.

"We are, comma, therefore, comma, unable to ..... hello, Mr. Watterly, be right with you in half a second ..... I'll finish this later, Miss Kettle ... thank you."

DIFFERENCES BETWEEN WRITTEN AND SPOKEN STYLES IN COMMUNICATION

	WRITTEN	SPOKEN
1.	Intended for the eye	Intended for the ear
2.	May be absorbed by the reader at his leisure.	Must be understood as delivered.
3.	Reader proceeds at his own pace.	Listener proceeds at speaker's pace.
4.	Reader can meditate, and consult outside sources.	Listener cannot reflect, or loses thread of remainder of speech.
5.	Must be ultimately intelligible to the reader.	Must be instantly intelligible to the listener.
6.	No feedback.	Allows for feedback.
7.	Contains few personal elements.	Contains personal elements.
8.	Language can be planned.	Language largely impromptu.
9.	Grammatical lapses are unacceptable.	Grammatical lapses are acceptable.

APPENDIX C

PREPARATION FOR A SITE VISIT

I COMPILE AND REVIEW INFORMATION ON PLANTS

1. Type of Plant Including Capacity

Sewage:
- Lagoon
- Primary
- Secondary
- Tertiary
- Special
- Package Plants
- On Site Disposal Systems

Water:
- Sedimentations
- Filtration
- Chemical Treatment

2. Contributory or User Sources

Sewage:
- Population
- Industrial and Commercial
- Waste Water Collection System (Sanitary Combined)
- Receiving Water Body Characteristics

Water:
- Population
- Industrial and Commercial
- Water Sources

3. Geographic - Climatic Effects

Sewage:
- Spring Run-off
- Period of Anaerobic Conditions in Lagoons
- Acceptance Capability of Receiving Waters

Water: - Seasonal Changes to Sources

- Quality and Quantity

4. Plant Influent and Effluent Characteristic

Sewage: - Volume

- Temperature

- Phosphate Chemical (BOD_5, PH, COD, SS, etc.)

Water: - Volumes

- Temperature

- Phosphate and Chemical (Colour, Turbidity, Hardness, etc.)

5. Indentification of Effluent Requirements

Sewage: - Allowable Chemical Content

- Minimum Chlorine Residuals

- Lagoons - Periods for Discharge

Water: - Allowable Chemical Content

- Minimum Chlorine and Fluorine Residuals

II COMPILE AND REVIEW INFORMATION RE: PLANT OPERATIONS

1. Flow Volumes (Average and Peaks)

- Daily

- Monthly

- Yearly

2. Details of Unit Operations

- Type of Units

- Capacities of Units

- Type and Quantity of Additives

- Pumping Units

3. Historical Data

- Age of Plant
- Modifications, Extension and Enlargements
- Planned Extensions or Modifications
- Power Sources and Emergency Facilities

4. Operating Authority and Staffing

- Operating Authority and Name of Senior Non-political Authority
- Name of Plant Superintendent and His Qualifications
- Names of Shift Foreman and Qualifications and Experience
- Number of Operators, Their role and Qualifications

5. Review of Available Relevant Documentary Material

- Design Drawings
- Operating Manuals
- Summaries of Operation Reports
- Last Year's Report

6. Prepare a Check List to be Followed at Time Of Inspection

- In Plant data Review
- Unit Inspections
- Trouble Areas From Previous Inspection
- Staff Discussions

7. On Site Considerations

- Advance Notice of Inspections
- Verbal Debriefing (operator in charge)
- Flexibility in Completion of Inspection
- Distribution of Reports

APPENDIX D

CHECK LIST - ROUTINE INSPECTION PROGRAM

SEWAGE

A. TREATMENT WORKS

- Updated system details of the plant
  - Units and capacities
- Flows from previous year
  - Average day flow for each month
  - Maximum day and date
  - Minimum day and date
  - Details of bypassing (emergency and planned)
    - Within the plant
    - Around the plant
    - Before the plant
- Population served
  - Within the municipality
  - External to the serviced unit (i.e. town)
  - Significant industrial flows where applicable
- Review of routine sampling program
  - Number, type and frequency of sampling
  - Problems with sampling
- Resumé of reported operational and loading problems
  - What is average effluent quality?
  - Review hydraulic and organic loading to identify significant trends
- List of reports of odours from sewage treatment works
  - From operating staff
  - From Air Management Branch

B. COLLECTOR SYSTEM

- Document the flushing, cleaning program
- Document problems (e.g. infiltration, abnormally high ground water, etc.)
- Obtain map of system
- Identify all points where potential bypass can take place and where storm sewers are interconnected

C. SEWAGE PUMPING STATIONS

- Updated system details for each station
  - Units and capacities
- Details of emergency alarm
- Details of arrangements to handle power outages at each station
- Overflow arrangements
- Actual details of location and size of the outfall
- (If possible) drawings showing areas tributary to pumping stations

II WATER SUPPLY

A. TREATMENT WORKS

- Updated system details of the source(s) of supply
  - Units, capacities, etc.
- Flows for previous year
  - Average day
  - Maximum day, date (reason)
  - Maximum hourly rate, date (reason)
  - Is any untreated water allowed to enter the distribution system?
- Population served
  - Within the municipality
  - External to the municipality
  - Significant industrial demands
- Review of bacteriological sampling program
  - Comparison against Ministry standards
- Resumé of complaints from reported problems
  - Taste or odour complaints
  - Low pressure complaints
  - Problems with inadequate flows for fire-fighting

B. DISTRIBUTION SYSTEM

- Details of routine maintenance program
  - Hydrants, valves
  - Flushing and swabbing programs
- Ensure that an adequate number of samples are being collected for each distribution system when several receive water from the same supply!

- List any problems

C. STORAGE

- Updated details on each storage works
- Details of inspection and maintenance program being carried out
- Listing of any problems

WATER WORKS REPORTS

MINIMUM INFORMATION FOR ROUTINE REPORTS
(where applicable)

1. Chlorination

   (a) Chlorine residual determinations, free and combined if possible, on samples collected;

   - on top of filter,
   - after the filter,
   - from the plant effluent, and
   - from the distribution system on occasions

   (b) Chlorinator settings, pre, post, etc.

   (c) Flow rates

   (d) From (b) and (c) calculate dosage rates in ppm

   (e) Chlorine feed rate in ppm during previous month

   (f) Chlorine on hand, number of cylinders

   (g) Feed rates and proportion details for ammonia, sodium chlorite and sulphur dioxide.

2. Fluoridation

   (a) Fluoridator setting

   (b) From 1(c) and 2(a) calculate dosage

   (c) Fluoride feed rate in ppm during previous month.

   (d) Review of fluoride analysis results.

3. Pre-Treatment

   (a) Chemical feed rates

   (b) Chemical dosage calculated from 1(c) and 3(a).

4. Filtration

   (a) Filter rates

   (b) Backwash rates

   (c) Head loss and length of runs.

5. Physical Analysis

   (a) Raw and treated turbidities at time of visit

   (b) Raw and treated colour at time of visit

   (c) Water temperature at time of visit.

6. Bacteriological Analysis - Distribution System Samples

   (a) Number of samples collected since either the last inspection or the beginning of the year.

   (b) Number of adverse samples.

7. Plant Records and Maintenance

   (a) Comment on records

   (b) Comment on the tidiness of the plant if it is very good or very bad.

8. Depending on the installation, information is required on:

   taste and odour problems;

   algae counts and problems;

iron treatment; filter runs, back wash detail;

softening plant operation

- chemical calculations; and

corrosion, check the Langier's Index if problems indicated.

9. System Detail

(a) New additions or alterations to water works should be listed in routine report.

(b) From time to time an up to date inventory or water works detail is required.

INFORMATION REQUIRED ON A YEARLY BASIS
(where applicable)

1. Flow

In I.G.D.	(a) average day
	(b) maximum day
	(c) maximum month
In I.G.	(d) population and per capita consumption

2. Fluoridation

Calculated feed - rate in ppm	average for year

3. Coagulants and Chemicals

Calculated feed rates of carbon, activated silica, alum, etc. in ppm.	(a) days used
	(b) average feed rate
	(c) maximum feed rate

4. Analysis

Physical, colour, turbidity and algae counts.	(a) averages
	(b) maximums
	(c) minimums
Chemical in ppm	(a) averages
	(b) maximums
Bacteriological	(a) samples collected from distribution system
	(b) adverse results on distribution system samples
	(c) log average of raw water coliform counts

5. Well data -

Operating level at given flow rates	(a) static level at beginning of year
	(b) static level at end of year
	(c) operating level at beginning of year
	(d) operating level at end of year
Well capacity	(e) operating well output in I.G.M.

COMPREHENSIVE REPORTS

As the work load permits comprehensive reports are required. These reports should include a review of planning detail, expansion plans, water quality, distribution system, treatment facilities, and storage facilities.

CONVENTIONAL ACTIVATED SLUDGE

WFCP INSPECTION

1. Check Screening: - Clean - no restriction in flow - How often are screens cleaned?

2. Grit Channels: - Clean - how often is it cleaned? How much grit is removed - shovels or barrels full of grit - pounds of grit - buried where?

3. Primary Tanks: - Skimmer - how is it operating? Is it ser low enough to remove material from the surface (liquid) - if not, is operator going to re-set the skimmer - if not, why not? - Weirs - are they clean? - appearance of primary effluent - how often are the weirs cleaned?

4. Aeration Tanks: - Take samples from the Raw Sewage - Primary Effluent - mixed liquor - final effluent. One sample (if no more are necessary) for chemical analysis. In addition, collect a sample for bacteriological examination from the final effluent.
- Ask for 5-day BOD, S.S. and Volatile Solids. In special cases it may be necessary to ask for additional analyses.
- Collect a sample in the cylinder from the Mixed Liquor for the suspended solids test. Define whether mechanical aeration or diffused air is used.
- Perform dissolved oxygen test on mixed liquor. 30 min. settling test gives you a percent settleable solids.

4. Aeration Tanks (continued)

- Microscopic examination of activated sludge to differentiate between the various subphylum (groups) of the protozoa and identify filamentious organisms. Classify conditions which have occurred, are occurring or will occurr within the activated sludge treatment process according to the defined protozoa.
- Perform the oxygen uptake test to measure the respiration rate of the organisms in the activated sludge process and determine the Specific Uptake Rate (SUR).
- Know the following primary effluent (5-day BOD, S.S.) - Plant flow - Aeration tank volume - MLSS - This information with the 30 Min. settling test results you can compute the SVI by the following formula:

$$SVI = \frac{\% \text{ Settleable Solids}}{\text{mg/l Suspended Solids}} \times 10{,}000$$

- A recommended or suggested SVI is 100 (no units). SVI gives you an idea of the settleability of your sludge.
- The 30 minute settling test in percent settleable solids times 100 gives you a comparison to make with the percent of actual sludge removed from the final claritier.
- Sludge Age - can be computed from the following formula:

$$SA \cdot \frac{F}{V} = MLSS$$

Where F = Plant flow in MGD
V = Volume of aeration tank in millions of gallons
MLSS = S.S. of mixed liquor (aeration tank) lab
S.S. = S.S. of primary effluent

A suggested SA is 3.5 days

$$SA = \frac{F \text{ in MGD}}{V \text{ in MG}} \times \frac{NLSS \text{ in mg/l}}{SS \text{ in mg/l}} = X \text{ days}$$

F/m - Food to micro-organisms ratio is the 100 lbs. of 5 day BOD/100 lbs. of suspended solids. The F/m is just the inverse of the Sludge Age.

5. Final Clarifier (settling tank) (rectangular) - only a circular tank can be called a clarifier as far as GEM is concerned

- Appearance of final clarifier effluent - Weirs - clean - how often are they cleaned? - Withdrawal rates of sludge from final clarifier - sludge usually returned to the aeration tank, it can be returned to the primary; usual practice calls for withdrawing sludge from the final clarifier to aeration tank and waste sludge to the primary.

6. Chlorine Contact Chamber

- Collect sample of the effluent and check chlorine residual. Check appearance of final effluent.

7. Digester

- How does the Plant Operator operate the digester? - find out the details. What mixing devices are available - Draft Tube Mixer - Gas Mixer - Heat Exchanger method of mixing - sludge removed from the bottom of the digester and passed through the heat exchanger then pumped back to the top of the digester.

- How often does he mix, for how long? Does he shut down mixers before taking supernatant and/or returning raw sludge?

- Collect samples from the digester raw sludge - digester sludge - supernatant. Ask for the following analyses -

7.	Digester (continued)	volatile solids - volatile acids - alkalinity - pH - percent moisture on raw sludge and digester sludge.

There are a number of differences that would occur in this procedure depending on the type of plant and the modifications of this process.

For instance: In Chicago Pump Plants you can compute the Sludge Age once you have performed the 30 minute settling test and if a graph is available plotting settleable solids versus suspended solids.

MUNICIPAL POLLUTION and/or SEWAGE TREATMENT REPORT (Suggested)

TITLE PAGE:

- report title
- list of officials
- date of report

TABLE OF CONTENTS: (an outline of reports contents)

- chapter headings
- illustrations, maps, graphs, tables, etc.

SUMMARY OF POLLUTION FINDINGS: (gives concise review of report findings) (quite condensed).

- outline of pollution situation
- suggested methods of correction
- estimated costs of improvements (if applicable)
- method of payment
- cost to individual taxpayer

INTRODUCTION & BACKGROUND: (very brief and lucid)

- scope of report and purpose of investigation
- associated engineering problems (investigation)
- provide description of studies, investigations and alternative corrective measures.

GENERAL SUMMARY:

- description of municipality of watershed, its size, drainage & other significant engineering facts;
- description of present facilities;
- existing agreements with other municipalities;
- specific engineering problems - drainage, flooding;

GENERAL SUMMARY: Continued:

- population, residential, commercial industrial also growth;
- water consumption and waste flows (details in appendix);
- industrial wastes;
- particular design criteria for facilities;
- application of OWRC Act where contradicted and other present by-laws;
- advantages to watershed - also disadvantages and other problems if any;

ALTERNATIVES:

- outline alternate solutions with advantages and disadvantages of each;
- if cost estimates made compare these - may present these in tabular form;

FINANCING IMPROVEMENTS:

- how accomplished - conventional or OWRC financing for debt as well as operation replacement, etc.

POLICY DECISIONS REQUIRED:

- existing by-laws - effects on water pollution abatement;
- new by laws - required for improvement
- policy decisions required to initiate action and abate pollution.

RECOMMENDATIONS & CONCLUSIONS:

- the recommended project which will best correct problem;
- financial arrangements (rare)
- by-laws required

RECOMMENDATIONS & CONCLUSIONS: Continued:

- policy decisions required
- OWRC Approval required

APPENDICES:

1. population, past, projected, analyses, etc.

2. municipal data: assessable frontage etc. (residential, commercial, etc.)

3. water consumption and waste waterflows (past and projected) - storm water effects avg. annual, max. day, max. hr.

4. WASTE WATER ANALYSES:
   - tabulation
   - interpretation
   - application to design
   - industrial waste characteristics

5. DESIGN: of System (where applicable)
   - criteria and application to data
   - hydraulics
   - special considerations
   - sizes of units, sewers, etc
   - layout of facilities
   - graphs, maps, tabulations
   - future needs

6. DESIGN: Treatment Works
   - design criteria and application
   - location and wind direction
   - hydraulic and loading computations
   - sizes of units, etc
   - layout

7. Soil Conditions

8. Cost Estimates

APPENDIX F

WATER POLLUTION REPORT

STREAM SURVEY

INTRODUCTION:

Include dates of the survey; persons interviewed; weather conditions at the time of sampling and previous to sampling.

DESCRIPTION OF STREAM & WATERSHED:

- stream origin and terminus.
- length of the river and the elevation at the headwaters and mouth of the river.
- mention of local gradients - re aeration and recovery zones.
- population in the watershed including the main populated area. List of centres and respective population figures of communities with populations of say above 1000 persons.
- pertinent geological information (eg. limestone formations which may be instrumental in spreading ground water pollution or suitability of land for septic tank systems (upper strata - sand, clay, etc.).
- types of agriculture and forested areas (extent of use of pesticides and their possible effect on the stream).
- location of major swamps and dams.

STREAM USAGE:

(a) Use of stream as a water supply, either municipal or private;

(b) Use of stream for waste disposal, either municipal or private;

(c) Use of stream for recreational purposes (municipal, private, etc.);

(d) Use of stream for navigation. Pollution originating from pleasure craft, etc.

STREAM FLOWS:

Gauging station records, if available. Otherwise, estimated flows. Dilution ration provided by stream for sewage flow from each municipality preferably in relation to low flows.

EXPLANATION OF LABORATORY ANALYSES:

Brief Resume of the meaning of BOD, solids, turbidity and M.F. Coliform Counts. The OWRC objectives outlined for stream water quality.

DISCUSSION OF SAMPLE RESULTS:

Location of sample points on accompanying map. Compare trends over the years and compare results with the OWRC objectives. Explain reasons for adverse quality of stream water, where applicable.

CONCLUSIONS:

A summary of the main findings relative to pollution. Any other pertinent comment.

RECOMMENDATIONS:

The action required to improve the condition of the stream.

APPENDIX G

INTRODUCTION TO PLANT INSPECTIONS

Definition of Purpose

(a) Ministry activity in the field of plant inspections encompasses a number of objectives. In broad terms these may be defined under the following headings:

(1) Regulatory

(2) Data Collection

(3) Measurement of Efficiency and Effectiveness

(4) Assistance to the Operators

(b) Regulatory

(1) Right to Inspect

Section 20 (1) of the OWR Act is the authority for the Ministry to carry out inspections, etc. It is quoted as follows:

"The Minister and his employees and agents may at any time for his purposes, without consent and without compensation, enter into lands or buildings of the Province or of any municipality or of any person, or into any highway or road under the jurisdiction and control of any public authority, or into any boat or ship to which the regulations under clause 17 of sub-section 1 of Section 62 apply, and may make such surveys, examinations, investigations, inspections or other arrangements as he considers necessary."

(2) Standards

Certain standards have been evolved by the Ministry detailing the quality of the 'products' of both water and sewage treatment plants. The details of these will be covered later, but as a first purpose then MOE inspections should establish the compliance or otherwise of the plant performance in comparison with these standards.

(3) Plant Capacity

The Planning Act together with policy and procedures developed by this Ministry, the Ministry of Housing and certain Municipal Governments requires this Ministry to comment favorably or unfavorably on land development projects. The second purpose then of the inspection is to establish the capability of the plant to service present and future development.

(c) Data Collection

Collection of data is important for a number of reasons. The first two have already been touched on. Data is necessary for the purposes of comparison to standards. It is also necessary to support recommendations in regard to proposed development. Data is, in addition, a requirement for comparison purposes with other plants, for development of new techniques, and as input to plant enlargement or modification decisions.

(d) Measurement of Efficiency and Effectiveness

Measurement of efficiency and effectiveness differs from a comparison to a standard in that both may be acceptable without an adequate comparison. The reverse may likewise be true, i.e. Ministry standards may be met by inefficient and ineffective plants. Efficiency and effectiveness may also be the first consideration in the approval or rejection of new development. As a final consideration, it is to be remembered that efficiency and effectiveness are not always synonymous.

(e) Assistance to Operating Authorites

This objective may well be the prime purpose in a number of instances. While the Ministry does provide facilities for training of operators, not only for those employed in Ministry operated plants, but also for both private and municipally operated plants. However, two weaknesses still remain. The first is a lack of any obligatory training or requirement for licensing, and the other is budgetary. We have examples, throughout the province, of large plants well equipped not only within the plant, but with excellent laboratory facilities and staffed in numerous instances with experts in the form of laboratory technicians and engineer supervisors. At the other end of the scale, we have plants of similar characteristics, except in scale, operated by semi or

unqualified staff and supervised by non-professionals. By default, if for no other reason, this Ministry must fulfill this latter role. Ministry staff also by reason of frequent visits to other plants are in the unique position of being able to pass on new ideas.

(f) In summary then, the purpose of a plant inspection can and must include the following considerations:

(1) The right and responsibility.

(2) Enforcement of regulation.

(3) Data collection.

(4) Efficiency and effectiveness.

(5) Assistance.

TYPES OF PLANTS

Plants in operation throughout the Province run the gamut from modified septic tanks to multi-million gallon per day tertiary treatment plant. They are operated by Ministry staff, by municipal staff and by the private sector. Ministry operated plants, who are also supervised by Ministry senior staff, will not be discussed further here. But the remainder do raise the question of the need for a variable approach insofar as the frequency and philosophy of inspections are concerned.

FREQUENCY

While the majority of plants operate on a year-round basis, it must not be forgotten that a large number of plants in recreational areas are operated on a seasonal basis. Inspections of the latter must, of course, be done during the operating season, and because of the shortness of that season one inspection should suffice. In the matter of year-round plants, probably three per year should suffice. The major effort would be after the completion of the plant's accounting period. The other two would be more liaison in nature.

WHO WILL CARRY OUT INSPECTION?

Most district offices are staffed with both technicians and engineers. The question of assigning responsibility for this activity must of necessity be with the managers and/or district officers.

REPORTS

A number of considerations must be taken into account with respect to

the need for a report and its content. In regard to the need for a report, there are two main purposes which justify its existence, communication and record keeping. Without at least one, the need for the report is without any rational foundation. In the matter of content, reference to the objectives of the inspection must be the criteria. Earlier, some five objectives were outlined. The report must include reference to each of these objectives.

Reports can be really classified into three as far as format is concerned - statistical or narrative or a combination of the two. The latter will apply here. There are definite advantages to standardization at least within a district, and perhaps thought should be given to province-wide standardization. Reports will vary somewhat of course, dependent on the type of plant under inspection. As a final word, care must be taken to ensure that the objective does not become an exercise in literary achievement to the detriment of the purpose of communcation and record keeping.

One further consideration is distribution of the report. The authority whose plant was the subject of the inspection must receive a copy. Distribution other than this should be closely controlled, especially if criticism is included.

TRAINING

The need for some form of training can probably be justified on the basis of a standardization of approach to the inspections. The training outline might well follow the objectives already outlined. Its purpose should include the ensuring of familiarity with techniques and processes of various plants, familiarity with Ministry standards and policies, the purpose of the inspection and the format for reporting. Some of this training is already given in other courses presently in place. Perhaps the objective of this course may be more properly stated as a definition of the philosphy behind the inspection. Certainly the emphasis should not be confined to technical considerations.

APPENDIX H

COURSE FOR ENVIRONMENTAL OFFICERS

INSPECTING WATER POLLUTION CONTROL PLANTS

Questions regarding sludge disposal.

Grit and Screenings

1. (a) Type of removal process (channels, aerated tanks, detritor, etc.).

   (b) Type of physical removal of grit; clam bucket, air lift, armstrong (hand shovel), etc.

2. Size of unit (design and actual measurements).

3. Rate of grit removal (cubic feet per million gallons sewage treated).

4. Estimate of percentage of organics versus non-organics in grit.

5. Frequency of removal of grit from plant.

6. Method of grit removal and who does the removal, and is the hauler certified by M.O.E.

7. (a) Where is the removed grit disposal of and is the site approved by M.O.E?

   (b) Is the grit disposal on plant grounds? What is the depth of the water table? Where is the closest water supply?

8. (a) Are the screenings combined with grit?

   (b) Is any chemical used to control odours and insects (i.e. chloride of lime).

9. Are comminutors or barminutors used ahead of grit removal or after grit removal?

10. (a) Is the removal process working properly? (i.e. any visible problems such as blowers not working or too much air causing grit carry over to clarifiers).

    (b) Is the volume of air sufficient to keep grit hopper functioning properly and to keep the organics in suspension in aerated channels to primary tanks. Should the blower speed be adjusted to change air flow. Is the blower constantly blowing off.

11. What other problems have been encountered by operating staff with respect to equipment or process? (i.e. is it overloaded hydraulically, are there plugging up conditions, or removal problems).

12. Are the Detritor directional vanes in the proper positions to prevent straight through flow.

13. Is there any other grit removal device used in the plant.

14. What is the approximate cost per year for grit disposal?

Sludge Disposal

1. (a) Type of process (raw, aerobic or anaerobic, drying process or incineration).

   (b) Type of sludge being treated; raw, aerobically or anaerobically digested, primary and secondary digested.

2. Size of units.

3. Rate of sludge removal per year (gallons of sludge per million gallons raw sewage).

4. Frequency of removal (i.e. hauling frequency).

5. Percentage volatiles in sludge disposed.

6. Who does the hauling and what type of vehicles are used?

7. Is the hauler certified for operation of a waste management system by M.O.E.?

8. Where is sludge disposed and are sites certified for waste disposal by M.O.E.?

9. Is scum from clarifiers handled with sludge or separately? If separate, answer questions 6, 7, and 8 for scum removal.

10. If anaerobic process used:

   (a) Is the digester gas used in plant or burned off?

   (b) Approximately what percentage of the gas produced is used or burned off?

   (c) What type of digester heating equipment is used and what type of fuel is used?

   (d) Is the digester mixing equipment installed?

(e) Is there digester gas storage at the plant?

(f) What is the quality of the supernatant from the digester.

11. If drying beds are used:

(a) What drying media is used?

(b) Where is drained liquid directed?

(c) How is dried sludge removed?

(d) What is the operating depth of the drying beds.

(e) Are the drying beds in continuous use throughout the year.

(f) Are some of the drying beds being kept as reserve for emergency storage of sludge.

12. Is any other dewatering device or sludge thickening process used other than drying beds? If so, please describe.

(a) What conditioning chemicals are used (lbs of chemical per dry ton of solids).

(b) What is the routine and annual maintenance.

13. Are any complaints recorded at the plant from the public regarding odours created by sludge at the plant or after removal from the plant?

14. Are there any noticeable odours around the plant at the time of inspection due to sludge dispoal process?

15. Are any problems being encountered in the sludge digestion process or dewatering (or drying) processes?

16. (a) Are any problems encountered with sludge hauler at the plant, on route to site or at disposal site?

(b) Does the plant operator physically inspect the sludge disposal sites on a routine basis (i.e. once a month).

17. Is sludge being utilized or simply disposed? If utilized how? What application rates being used?

18. What is the approximate cost per year for sludge hauling including any conditioning chemicals required? What is chemical costs per ton of dry solids removed?

19. Are any plans underway to change or modify sludge disposal process? Have any changes been made during past year which have not been previously recorded?

Introduction to Tables

The following Tables present the relationship of measured head (H) to discharge (Q) for various types and sizes of open channel primary elements. The formulas employed in calculating these relationships are obtained from the following sources:

Device	Source
V-Notch Weirs	British Standard 3680, Part 4A (1965), Methods of Measurement of Liquid Flow in Open Channels, Thin Plate Weirs and Flumes
Rectangular Weir With End Contractions	
Full Width Rectangular Weir	
Cipolletti Weir	Water Measurement Manual, 2nd Edition (1974) United States Department of the Interior, Bureau of Reclamation
Parshall Flume	

An effort has been made in the preparation of these Tables to incorporate only the recommended range of measured heads appropriate to the type and size of primary element. For further information relating to primary element geometry and limits of application, reference should be made to the source documents.

Sizing of the primary element in the case of the parshall flume is based upon the width of the flume throat. In the case of rectangular or Cipolletti weirs sizing is based upon the crest length of the weir.

The Tables are presented in units of feet for the measured head (H) and million imperial gallons per day (MIGD) for the discharge (Q). The head-discharge formulas, however, employ units of

feet for the measured head (H) and cubic feet per second (cfs) for the discharge (Q). These units are employed in the formulas in order to maintain dimensional consistency.

The discharge in cfs is converted to MIGD through use of the appropriate conversion factor indicated in the Tables.

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TABLE 1 DISCHARGE FOR A 90° V-NOTCH WEIR.

FORMULA $Q = 2.478\ H_1^{2.5}$

$H_1 = (H + .003)$

H - Measured head/feet

Q - Discharge/cfs

MIGD = .539 X cfs

Head (ft.)	0.00	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09
0.100	0.005	0.006	0.007	0.009	0.010	0.012	0.014	0.017	0.019	0.022
0.200	0.025	0.028	0.031	0.035	0.039	0.043	0.047	0.052	0.057	0.062
0.300	0.067	0.073	0.079	0.085	0.092	0.099	0.106	0.113	0.121	0.129
0.400	0.138	0.146	0.155	0.165	0.174	0.184	0.195	0.206	0.217	0.228
0.500	0.240	0.252	0.264	0.277	0.290	0.304	0.318	0.332	0.347	0.362
0.600	0.377	0.393	0.409	0.426	0.443	0.460	0.478	0.496	0.515	0.534
0.700	0.553	0.573	0.594	0.614	0.636	0.657	0.679	0.702	0.725	0.748
0.800	0.772	0.796	0.821	0.846	0.871	0.898	0.924	0.951	0.979	1.007
0.900	1.035	1.064	1.093	1.123	1.153	1.184	1.216	1.247	1.280	1.312
1.000	1.346	1.379	1.414	1.449	1.484	1.520	1.556	1.593	1.630	1.668
1.100	1.707	1.746	1.785	1.825	1.866	1.907	1.948	1.990	2.033	2.076
1.200	2.120	2.164	2.209	2.255	2.301	2.347	2.394	2.442	2.490	2.539

cont'd.....

TABLE 1 (cont'd)

Head (ft.)	0.00	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09
1.300	2.589	2.638	2.689	2.740	2.792	2.844	2.897	2.950	3.004	3.059
1.400	3.114	3.170	3.226	3.283	3.341	3.399	3.458	3.517	3.577	3.638
1.500	3.699	3.761	3.823	3.886	3.950	4.014	4.079	4.145	4.211	4.278
1.600	4.345	4.413	4.482	4.552	4.622	4.692	4.763	4.835	4.908	4.981
1.700	5.055	5.130	5.205	5.281	5.357	5.434	5.512	5.591	5.670	5.750
1.800	5.830	5.911	5.993	6.076	6.159	6.243	6.327	6.413	6.499	6.585
1.900	6.672	6.760	6.849	6.939	7.029	7.119	7.211	7.303	7.396	7.490

TABLE 2 DISCHARGE FOR A 60^{o} V-NOTCH WEIR

FORMULA $Q = 1.426\ H_1^{2.5}$

$H_1 = (H + .004)$

H - Measured head/feet

Q - Discharge/cfs

MIGD = .539 X cfs

Head (ft.)	0.00	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09
0.100	0.003	0.003	0.004	0.005	0.006	0.007	0.008	0.010	0.011	0.013
0.200	0.014	0.016	0.018	0.020	0.023	0.025	0.027	0.030	0.033	0.036
0.300	0.039	0.042	0.046	0.049	0.053	0.057	0.061	0.066	0.070	0.075
0.400	0.080	0.085	0.090	0.095	0.101	0.107	0.113	0.119	0.125	0.132
0.500	0.138	0.145	0.153	0.160	0.168	0.175	0.183	0.192	0.200	0.209
0.600	0.218	0.227	0.236	0.246	0.256	0.266	0.276	0.286	0.297	0.308
0.700	0.319	0.331	0.343	0.355	0.367	0.379	0.392	0.405	0.418	0.432
0.800	0.445	0.459	0.473	0.488	0.503	0.518	0.533	0.549	0.564	0.581
0.900	0.597	0.614	0.630	0.648	0.665	0.683	0.701	0.719	0.738	0.757
1.000	0.776	0.795	0.815	0.835	0.856	0.876	0.897	0.918	0.940	0.962
1.100	0.984	1.006	1.029	1.052	1.075	1.099	1.123	1.147	1.172	1.197
1.200	1.222	1.248	1.273	1.300	1.326	1.353	1.380	1.408	1.435	1.463

cont'd.....

Table 2 (cont'd)

Head	0.00	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09
1.300	1.492	1.521	1.550	1.579	1.609	1.639	1.669	1.700	1.731	1.763
1.400	1.795	1.827	1.859	1.892	1.925	1.959	1.993	2.027	2.061	2.096
1.500	2.131	2.167	2.203	2.239	2.276	2.313	2.351	2.388	2.426	2.465
1.600	2.504	2.543	2.582	2.622	2.663	2.703	2.744	2.786	2.828	2.870
1.700	2.912	2.955	2.999	3.042	3.086	3.131	3.176	3.221	3.266	3.312
1.800	3.359	3.406	3.453	3.500	3.548	3.596	3.645	3.694	3.744	3.794
1.900	3.844	3.894	3.946	3.997	4.049	4.101	4.154	4.207	4.260	4.314

TABLE 3 DISCHARGE FOR A 45° V-NOTCH WEIR

FORMULA $Q = 1.028\ H_1^{2.5}$

H_1 = Measured head/feet

H - Measured head/feet

Q - Discharge/cfs

MIGD = .539 X cfs

Head (ft.)	0.00	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09
0.100	0.002	0.002	0.003	0.004	0.004	0.005	0.006	0.007	0.008	0.009
0.200	0.011	0.012	0.013	0.015	0.016	0.018	0.020	0.022	0.024	0.026
0.300	0.028	0.031	0.033	0.036	0.039	0.042	0.045	0.048	0.051	0.054
0.400	0.058	0.061	0.065	0.069	0.073	0.077	0.082	0.086	0.091	0.096
0.500	0.100	0.105	0.111	0.116	0.121	0.127	0.133	0.139	0.145	0.151
0.600	0.158	0.164	0.171	0.178	0.185	0.192	0.200	0.207	0.215	0.223
0.700	0.231	0.240	0.248	0.257	0.265	0.274	0.284	0.293	0.303	0.312
0.800	0.322	0.332	0.343	0.353	0.364	0.375	0.386	0.397	0.408	0.420
0.900	0.432	0.444	0.456	0.468	0.481	0.494	0.507	0.520	0.534	0.547
1.000	0.561	0.575	0.589	0.604	0.619	0.633	0.649	0.664	0.679	0.695
1.100	0.711	0.727	0.744	0.760	0.777	0.794	0.812	0.829	0.847	0.865
1.200	0.883	0.902	0.920	0.939	0.958	0.978	0.997	1.017	1.037	1.057

cont'd.....

TABLE 3 (cont'd)

Head (ft.)	0.00	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09
1.300	1.078	1.099	1.120	1.141	1.162	1.184	1.206	1.228	1.251	1.274
1.400	1.297	1.320	1.343	1.367	1.391	1.415	1.439	1.464	1.489	1.514
1.500	1.540	1.565	1.591	1.618	1.644	1.671	1.698	1.725	1.752	1.780
1.600	1.808	1.837	1.865	1.894	1.923	1.952	1.982	2.012	2.042	2.073
1.700	2.103	2.134	2.165	2.197	2.229	2.261	2.293	2.326	2.359	2.392
1.800	2.425	2.459	2.493	2.527	2.562	2.597	2.632	2.667	2.703	2.739
1.900	2.775	2.812	2.849	2.886	2.923	2.961	2.999	3.037	3.076	3.115

TABLE 4 DISCHARGE FOR A 22.5° V-NOTCH WEIR

FORMULA $Q = .502\ H_1^{2.5}$ Q - Discharge/cfs

$H_1 = (H + .009)$ MIGD = .539 X CFS

H - Measured head/feet

Head (ft.)	0.00	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09
0.100	0.001	0.001	0.002	0.002	0.002	0.003	0.003	0.004	0.004	0.005
0.200	0.005	0.006	0.007	0.008	0.008	0.009	0.010	0.011	0.012	0.013
0.300	0.014	0.016	0.017	0.018	0.019	0.021	0.022	0.024	0.026	0.027
0.400	0.029	0.031	0.033	0.035	0.037	0.039	0.041	0.043	0.045	0.048
0.500	0.050	0.053	0.055	0.058	0.060	0.063	0.066	0.069	0.072	0.075
0.600	0.078	0.082	0.085	0.088	0.092	0.095	0.099	0.103	0.107	0.111
0.700	0.115	0.119	0.123	0.127	0.131	0.136	0.140	0.145	0.150	0.154
0.800	0.159	0.164	0.169	0.175	0.180	0.185	0.191	0.196	0.202	0.207
0.900	0.213	0.219	0.225	0.231	0.238	0.244	0.250	0.257	0.263	0.270
1.000	0.277	0.284	0.291	0.298	0.305	0.312	0.320	0.327	0.335	0.343
1.100	0.351	0.359	0.367	0.375	0.383	0.392	0.400	0.409	0.417	0.426
1.200	0.435	0.444	0.453	0.463	0.472	0.482	0.491	0.501	0.511	0.521

cont'd.....

TABLE 4 (cont'd)

Head (ft.)	0.00	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09
1.300	0.531	0.541	0.551	0.562	0.572	0.583	0.594	0.605	0.616	0.627
1.400	0.638	0.649	0.661	0.673	0.684	0.696	0.708	0.720	0.732	0.745
1.500	0.757	0.770	0.783	0.796	0.809	0.822	0.835	0.848	0.862	0.875
1.600	0.889	0.903	0.917	0.931	0.945	0.960	0.974	0.989	1.004	1.019
1.700	1.034	1.049	1.064	1.080	1.095	1.111	1.127	1.143	1.159	1.175
1.800	1.192	1.208	1.225	1.242	1.259	1.276	1.293	1.310	1.328	1.345
1.900	1.363	1.381	1.399	1.417	1.436	1.454	1.473	1.492	1.511	1.530

TABLE 5 DISCHARGE PER FOOR OF CREST LENGTH FOR A FULL WIDTH RECTANGULAR WEIR

FORMULA $Q = 3.419\ b\ H_1^{1.5}$

$H_1 = (H + .003)$

H - Measured head/feet

Q - Discharge/cfs

b - Width of weir crest/feet

MIGD = .539 X cfs

Head (ft.)	0.00	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09
0.100	0.061	0.070	0.079	0.089	0.100	0.110	0.121	0.133	0.144	0.156
0.200	0.169	0.181	0.194	0.207	0.221	0.235	0.249	0.263	0.277	0.292
0.300	0.307	0.323	0.338	0.354	0.370	0.387	0.403	0.420	0.437	0.454
0.400	0.471	0.489	0.507	0.525	0.543	0.562	0.581	0.599	0.619	0.638
0.500	0.657	0.677	0.697	0.717	0.737	0.758	0.778	0.799	0.820	0.842
0.600	0.863	0.884	0.906	0.928	0.950	0.972	0.995	1.017	1.040	1.063
0.700	1.086	1.109	1.133	1.156	1.180	1.204	1.228	1.252	1.277	1.301
0.800	1.326	1.351	1.376	1.401	1.426	1.452	1.477	1.503	1.529	1.555
0.900	1.581	1.608	1.634	1.661	1.688	1.714	1.742	1.769	1.796	1.824
1.000	1.851	1.879	1.907	1.935	1.963	1.991	2.020	2.048	2.077	2.106
1.100	2.135	2.164	2.193	2.222	2.252	2.282	2.311	2.341	2.371	2.401
1.200	2.432	2.462	2.492	2.523	2.554	2.585	2.616	2.647	2.678	2.709

cont'd.....

TABLE 5 (cont'd)

Head (ft.)	0.00	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09
1.300	2.732	2.763	2.795	2.827	2.859	2.891	2.923	2.955	2.987	3.020
1.400	3.053	3.085	3.118	3.151	3.184	3.218	3.251	3.284	3.318	3.352
1.500	3.386	3.419	3.453	3.488	3.522	3.556	3.591	3.625	3.660	3.695
1.600	3.730	3.765	3.800	3.835	3.870	3.906	3.941	3.977	4.013	4.049
1.700	4.085	4.121	4.157	4.193	4.230	4.266	4.303	4.340	4.376	4.413
1.800	4.450	4.488	4.525	4.562	4.600	4.637	4.675	4.712	4.750	4.788
1.900	4.826	4.864	4.903	4.941	4.980	5.018	5.057	5.096	5.134	5.173

TABLE 6 DISCHARGE PER FOOT OF CREST LENGTH FOR A CIPOLLETTI WEIR

FORMULA $Q = 3.367\ b\ H^{1.5}$

H - Measured head/feet

Q - Discharge/cfs

b - Width of weir crest/feet

MIGD = .539 X cfs

Head (ft.)	0.00	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09
0.200	0.162	0.175	0.187	0.200	0.213	0.227	0.241	0.255	0.269	0.283
0.300	0.298	0.313	0.329	0.344	0.360	0.376	0.392	0.408	0.425	0.442
0.400	0.459	0.476	0.494	0.512	0.530	0.548	0.566	0.585	0.604	0.622
0.500	0.642	0.661	0.681	0.700	0.720	0.740	0.761	0.781	0.802	0.822
0.600	0.843	0.865	0.886	0.907	0.929	0.951	0.973	0.995	1.018	1.040
0.700	1.063	1.086	1.109	1.132	1.155	1.179	1.202	1.226	1.250	1.274
0.800	1.299	1.323	1.348	1.372	1.397	1.422	1.447	1.473	1.498	1.524
0.900	1.550	1.575	1.601	1.628	1.654	1.680	1.707	1.734	1.761	1.788
1.000	1.815	1.842	1.870	1.897	1.925	1.953	1.981	2.009	2.037	2.065
1.100	2.094	2.122	2.151	2.180	2.209	2.238	2.267	2.297	2.326	2.356
1.200	2.386	2.416	2.446	2.476	2.506	2.536	2.567	2.597	2.628	2.659
1.300	2.690	2.721	2.752	2.784	2.815	2.847	2.878	2.910	2.942	2.974

cont'd....

TABLE 6 (cont'd)

Head (ft.)	0.00	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09
1.400	3.006	3.039	3.071	3.103	3.136	3.169	3.202	3.235	3.268	3.301
1.500	3.334	3.367	3.401	3.435	3.468	3.502	3.536	3.570	3.604	3.639
1.600	3.673	3.707	3.742	3.777	3.812	3.846	3.881	3.917	3.952	3.987
1.700	4.023	4.058	4.094	4.130	4.165	4.201	4.237	4.274	4.310	4.346
1.800	4.383	4.419	4.456	4.493	4.530	4.567	4.604	4.641	4.678	4.715
1.900	4.753	4.791	4.828	4.866	4.904	4.942	4.980	5.018	5.056	5.095

TABLE 7 DISCHARGE FOR A 1 FOOT RECTANGULAR WEIR WITH END CONTRACTIONS

FORMULA $Q = 5.350\ C_D bH^{1.5}$

H - Measured head/feet

Q - Discharge/cfs

b - Width of weir crest/feet

C_D - Coefficient of discharge

$C_D = 0.616\ (1-0.1\ H/b)$

MIGD = .539 X cfs

Head (ft.)	0.00	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09
0.200	0.156	0.168	0.180	0.192	0.205	0.218	0.231	0.244	0.258	0.272
0.300	0.286	0.300	0.315	0.330	0.345	0.360	0.376	0.392	0.408	0.424
0.400	0.440	0.457	0.474	0.491	0.508	0.525	0.543	0.561	0.579	0.597

TABLE 8 DISCHARGE FOR A 1.5 FOOT RECTANGULAR WEIR WITH END CONTRACTIONS

FORMULA $Q = 5.350\ C_D b H^{1.5}$

H - Measured head/feet

Q - Discharge/cfs

b - Width of weir crest/feet

C_D - Coefficient of discharge

$C_D = 0.616\ (1-0.1\ H/b)$

MIGD = .539 X cfs

Head (ft.)	0.00	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09
0.200	0.235	0.253	0.271	0.290	0.309	0.329	0.349	0.369	0.390	0.411
0.300	0.432	0.454	0.476	0.498	0.521	0.544	0.568	0.592	0.616	0.640
0.400	0.665	0.690	0.716	0.741	0.767	0.794	0.820	0.847	0.874	0.902
0.500	0.929	0.958	0.986	1.014	1.043	1.072	1.102	1.131	1.161	1.191
0.600	1.222	1.253	1.283	1.315	1.346	1.378	1.410	1.442	1.474	1.507
0.700	1.540	1.573	1.606	1.640	1.674	1.708	1.742	1.776	1.811	1.846

TABLE 9 DISCHARGE FOR A 2.0 FOOT RECTANGULAR WEIR WITH END CONTRACTIONS

FORMULA $Q = 5.350\ C_D bH^{1.5}$

H - Measured head/feet

Q - Discharge/cfs

b - Width of weir crest/feet

C_D - Coefficient of discharge

$C_D = 0.616\ (1-0.1\ H/b)$

MIGD = .539 X cfs

Head (ft.)	0.00	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09
0.200	0.315	0.338	0.363	0.388	0.414	0.440	0.466	0.493	0.521	0.549
0.300	0.578	0.607	0.637	0.667	0.697	0.728	0.760	0.792	0.824	0.857
0.400	0.890	0.923	0.957	0.992	1.027	1.062	1.097	1.133	1.170	1.206
0.500	1.243	1.281	1.319	1.357	1.396	1.435	1.474	1.514	1.554	1.594
0.600	1.635	1.676	1.717	1.759	1.801	1.843	1.886	1.929	1.972	2.016
0.700	2.060	2.104	2.149	2.194	2.239	2.284	2.330	2.376	2.423	2.470
0.800	2.517	2.564	2.612	2.660	2.708	2.756	2.805	2.854	2.903	2.953
0.900	3.003	3.053	3.104	3.154	3.205	3.257	3.308	3.360	3.412	3.465

TABLE 10 DISCHARGE FOR A 2.5 FOOT RECTANGULAR WEIR WITH END CONTRACTIONS

FORMULA $Q = 5.350\ C_D bH^{1.5}$

H - Measured head/feet

Q - Discharge/cfs

b - Width of weir crest/feet

C_D - Coefficient of discharge

C_D - 0.616 (1-0.1 H/b)

MIGD = .539 X cfs

Head (ft.)	0.00	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09
0.200	0.394	0.424	0.455	0.486	0.518	0.551	0.584	0.618	0.653	0.688
0.300	0.724	0.760	0.797	0.835	0.873	0.912	0.952	0.991	1.032	1.073
0.400	1.114	1.157	1.199	1.242	1.286	1.330	1.374	1.419	1.465	1.511
0.500	1.559	1.604	1.652	1.700	1.748	1.797	1.846	1.896	1.946	1.996
0.600	2.047	2.099	2.151	2.203	2.256	2.309	2.362	2.416	2.471	2.525
0.700	2.580	2.635	2.691	2.748	2.804	2.861	2.919	2.977	3.035	3.093
0.800	3.152	3.211	3.271	3.331	3.392	3.452	3.513	3.575	3.637	3.699
0.900	3.761	3.824	3.887	3.951	4.015	4.079	4.144	4.209	4.274	4.339
1.000	4.405	4.472	4.538	4.605	4.672	4.740	4.808	4.876	4.944	5.013
1.100	5.082	5.152	5.222	5.292	5.362	5.433	5.504	5.575	5.647	5.719
1.200	5.791	5.863	5.936	6.009	6.083	6.157	6.231	6.305	6.380	6.454

TABLE 11 DISCHARGE FOR A 3.0 FOOT RECTANGULAR WEIR WITH END CONTRACTIONS

FORMULA $Q = 5.350\ C_D bH^{1.5}$

H - Measured head/feet

Q - Discharge/cfs

b - Width of weir crest/feet

C_D - Coefficient of discharge

$C_D = 0.616\ (1-0.1\ H/b)$

MIGD = .539 X cfs

Head (ft.)	0.00	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09
0.200	0.473	0.509	0.546	0.584	0.622	0.662	0.702	0.743	0.784	0.827
0.300	0.870	0.914	0.958	1.003	1.049	1.096	1.143	1.191	1.240	1.289
0.400	1.339	1.390	1.441	1.493	1.545	1.598	1.651	1.706	1.760	1.816
0.500	1.872	1.928	1.985	2.042	2.101	2.159	2.218	2.278	2.338	2.399
0.600	2.460	2.522	2.584	2.647	2.710	2.774	2.838	2.903	2.968	3.034
0.700	3.100	3.167	3.234	3.302	3.370	3.439	3.507	3.577	3.647	3.717
0.800	3.788	3.859	3.931	4.003	4.075	4.148	4.222	4.296	4.370	4.445
0.900	4.520	4.595	4.671	4.747	4.824	4.901	4.979	5.057	5.135	5.214
1.000	5.293	5.373	5.453	5.533	5.614	5.695	5.777	5.859	5.941	6.024
1.100	6.107	6.190	6.274	6.359	6.443	6.529	6.613	6.699	6.785	6.872
1.200	6.958	7.046	7.133	7.221	7.309	7.398	7.487	7.576	7.666	7.756
1.300	7.846	7.937	8.028	8.119	8.211	8.303	8.396	8.489	8.581	8.675
1.400	8.769	8.863	8.957	9.052	9.147	9.243	9.338	9.434	9.531	9.628

TABLE 12 DISCHARGE FOR A 3.5 FOOT RECTANGULAR WEIR WITH END CONTRACTIONS

FORMULA $Q = 5.350\ C_D bH^{1.5}$

H - Measured head/feet

Q - Discharge/cfs

b - Width of weir crest/feet

C_D - Coefficient of discharge

$C_D = 0.616\ (1-0.1\ H/b)$

MIGD = .539 X cfs

Head (ft.)	0.00	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09
0.200	0.553	0.595	0.638	0.682	0.727	0.773	0.820	0.867	0.916	0.965
0.300	1.016	1.067	1.119	1.172	1.226	1.280	1.335	1.391	1.448	1.506
0.400	1.564	1.623	1.683	1.743	1.804	1.866	1.929	1.992	2.056	2.120
0.500	2.186	2.251	2.318	2.385	2.453	2.521	2.591	2.660	2.731	2.801
0.600	2.873	2.945	3.018	3.091	3.165	3.239	3.315	3.390	3.466	3.543
0.700	3.620	3.698	3.777	3.856	3.935	4.015	4.096	4.177	4.258	4.341
0.800	4.423	4.506	4.590	4.674	4.759	4.844	4.930	5.016	5.103	5.190
0.900	5.278	5.366	5.455	5.544	5.634	5.724	5.814	5.906	5.997	6.089
1.000	6.182	6.275	6.369	6.462	6.556	6.651	6.746	6.842	6.938	7.035
1.100	7.132	7.229	7.327	7.425	7.524	7.623	7.723	7.823	7.924	8.025
1.200	8.126	8.228	8.330	8.433	8.536	8.639	8.743	8.847	8.952	9.057
1.300	9.163	9.268	9.375	9.482	9.589	9.696	9.804	9.913	10.021	10.130

cont'd.....

TABLE 12 (cont'd)

Head (ft.)	0.00	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09
1.400	10.240	10.350	10.460	10.571	10.682	10.793	10.905	11.017	11.130	11.243
1.500	11.356	11.470	11.584	11.699	11.814	11.929	12.045	12.161	12.277	12.394
1.600	12.511	12.628	12.746	12.864	12.983	13.102	13.221	13.341	13.461	13.581
1.700	13.702	13.823	13.944	14.066	14.188	14.311	14.433	14.557	14.680	14.804

TABLE 13 DISCHARGE FOR A 4.0 FOOT RECTANGULAR WEIR WITH END CONTRACTIONS

FORMULA $Q = 5.350\ C_D bH^{1.5}$

H - Measured head/feet

Q - Discharge/cfs

b - Width of weir crest/feet

C_D - Coefficient of discharge

$C_D = 0.616\ (1-0.1\ H/b)$

MIGD = .539 X cfs

Head (ft.)	0.00	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09
0.200	0.632	0.680	0.730	0.780	0.831	0.884	0.937	0.992	1.047	1.104
0.300	1.162	1.220	1.280	1.340	1.402	1.464	1.527	1.591	1.656	1.722
0.400	1.789	1.856	1.924	1.993	2.063	2.134	2.206	2.278	2.351	2.425
0.500	2.500	2.575	2.651	2.728	2.805	2.884	2.963	3.042	3.123	3.204
0.600	3.286	3.368	3.451	3.535	3.620	3.705	3.791	3.877	3.964	4.052
0.700	4.141	4.230	4.319	4.410	4.500	4.592	4.684	4.777	4.870	4.964
0.800	5.059	5.154	5.250	5.346	5.443	5.540	5.638	5.737	5.836	5.936
0.900	6.036	6.137	6.239	6.341	6.443	6.546	6.650	6.754	6.859	6.964
1.000	7.070	7.176	7.283	7.390	7.498	7.607	7.716	7.825	7.935	8.045
1.100	8.156	8.268	8.380	8.492	8.605	8.719	8.833	8.947	9.062	9.178
1.200	9.293	9.410	9.527	9.644	9.762	9.880	9.999	10.118	10.238	10.358
1.300	10.479	10.600	10.722	10.844	10.966	11.089	11.213	11.337	11.461	11.586

cont'd.....

TABLE 13 (cont'd)

Head (ft.)	0.00	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09
1.400	11.711	11.837	11.963	12.090	12.217	12.344	12.472	12.600	12.729	12.858
1.500	12.988	13.118	13.249	13.380	13.511	13.643	13.775	13.908	14.041	14.174
1.600	14.308	14.443	14.577	14.713	14.848	14.984	15.121	15.257	15.395	15.532
1.700	15.670	15.809	15.948	16.087	16.227	16.367	16.507	16.648	16.789	16.931
1.800	17.073	17.216	17.359	17.502	17.645	17.790	17.934	18.079	18.224	18.370
1.900	18.516	18.662	18.809	18.956	19.103	19.251	19.399	19.548	19.697	19.847

TABLE 14 DISCHARGE FOR A 4.5 FOOT RECTANGULAR WEIR WITH END CONTRACTIONS

FORMULA $Q = 5.350\ C_D bH^{1.5}$

H - Measured head/feet

Q - Discharge/cfs

b - Width of weir crest/feet

C_D - Coefficient of discharge

$C_D = 0.616\ (1-0.1\ H/b)$

MIGD = .539 X cfs

Head (ft.)	0.00	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09
0.200	0.712	0.766	0.821	0.878	0.936	0.995	1.055	1.116	1.179	1.243
0.300	1.308	1.374	1.441	1.509	1.578	1.648	1.719	1.791	1.864	1.938
0.400	2.013	2.089	2.166	2.244	2.323	2.402	2.483	2.564	2.646	2.730
0.500	2.814	2.898	2.984	3.071	3.158	3.246	3.335	3.425	3.515	3.606
0.600	3.699	3.791	3.885	3.979	4.074	4.170	4.267	4.364	4.462	4.561
0.700	4.661	4.761	4.862	4.963	5.066	5.169	5.273	5.377	5.482	5.588
0.800	5.694	5.801	5.909	6.018	6.127	6.236	6.347	6.458	6.569	6.682
0.900	6.795	6.908	7.022	7.137	7.253	7.369	7.485	7.603	7.720	7.839
1.000	7.958	8.078	8.198	8.319	8.440	8.562	8.685	8.808	8.932	9.056
1.100	9.181	9.306	9.433	9.559	9.686	9.814	9.942	10.071	10.201	10.331
1.200	10.461	10.592	10.724	10.856	10.988	11.122	11.255	11.390	11.524	11.660
1.300	11.795	11.932	12.069	12.206	12.344	12.483	12.621	12.761	12.901	13.041

cont'd....

TABLE 14 (cont'd)

Head (ft.)	0.00	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09
1.400	13.182	13.324	13.466	13.608	13.751	13.895	14.039	14.183	14.328	14.474
1.500	14.620	14.766	14.913	15.060	15.208	15.357	15.506	15.655	15.805	15.955
1.600	16.106	16.257	16.409	16.561	16.713	16.867	17.020	17.174	17.329	17.484
1.700	17.639	17.795	17.951	18.108	18.265	18.423	18.581	18.740	18.899	19.058
1.800	19.218	19.378	19.539	19.701	19.862	20.024	20.187	20.350	20.513	20.677
1.900	20.842	21.006	21.172	21.337	21.503	21.670	21.837	22.004	22.172	22.340

TABLE 15 DISCHARGE FOR A 5.0 FOOT RECTANGULAR WEIR WITH END CONTRACTIONS

FORMULA $Q = 5.350\ C_D bH^{1.5}$

H - Measured head/feet

Q - Discharge/cfs

b - Width of weir crest/feet

C_D - Coefficient of discharge

$C_D = 0.616\ (1-0.1\ H/b)$

MIGD = .539 X cfs

Head (ft.)	0.00	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09
0.200	0.791	0.851	0.913	0.976	1.040	1.106	1.173	1.241	1.311	1.381
0.300	1.454	1.527	1.601	1.677	1.754	1.832	1.911	1.991	2.072	2.155
0.400	2.238	2.322	2.408	2.494	2.582	2.670	2.760	2.850	2.942	3.034
0.500	3.128	3.222	3.317	3.413	3.510	3.608	3.707	3.807	3.907	4.009
0.600	4.111	4.215	4.319	4.423	4.529	4.636	4.743	4.851	4.960	5.070
0.700	5.181	5.292	5.404	5.517	5.631	5.746	5.861	5.977	6.094	6.211
0.800	6.330	6.449	6.569	6.689	6.810	6.932	7.055	7.178	7.303	7.427
0.900	7.553	7.679	7.806	7.934	8.062	8.191	8.321	8.451	8.582	8.714
1.000	8.846	8.979	9.113	9.247	9.382	9.518	9.654	9.791	9.929	10.067
1.100	10.206	10.345	10.485	10.626	10.767	10.909	11.052	11.195	11.339	11.483
1.200	11.629	11.774	11.920	12.067	12.215	12.363	12.511	12.661	12.811	12.961
1.300	13.112	13.264	13.416	13.568	13.722	13.876	14.030	14.185	14.341	14.497

cont'd.....

TABLE 15 (cont'd)

Head (ft.)	0.00	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09
1.400	14.654	14.811	14.969	15.127	15.286	15.446	15.606	15.766	15.927	16.089
1.500	16.251	16.414	16.577	16.741	16.906	17.071	17.236	17.402	17.569	17.736
1.600	17.903	18.071	18.240	18.409	18.579	18.749	18.920	19.091	19.263	19.435
1.700	19.608	19.781	19.955	20.129	20.304	20.479	20.655	20.831	21.008	21.185
1.800	21.363	21.541	21.720	21.899	22.079	22.259	22.440	22.621	22.803	22.985
1.900	23.168	23.351	23.534	23.719	23.903	24.088	24.274	24.460	24.646	24.833

TABLE 16 DISCHARGE FOR A 3 INCH PARSHALL FLUME

FORMULA $Q = 1.0\ H_a^{1.468}$

H_a - Measured head/feet

Q - Discharge/cfs

MIGD = .539 X cfs

Head (ft.)	0.00	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09
0.100	0.018	0.021	0.024	0.027	0.030	0.033	0.037	0.040	0.043	0.047
0.200	0.051	0.055	0.058	0.062	0.066	0.070	0.075	0.079	0.083	0.088
0.300	0.092	0.097	0.101	0.106	0.111	0.115	0.120	0.125	0.130	0.135
0.400	0.140	0.146	0.151	0.156	0.162	0.167	0.172	0.178	0.184	0.189
0.500	0.195	0.201	0.206	0.212	0.218	0.224	0.230	0.236	0.242	0.248
0.600	0.255	0.261	0.267	0.274	0.280	0.286	0.293	0.299	0.306	0.313
0.700	0.319	0.326	0.333	0.340	0.346	0.353	0.360	0.367	0.374	0.381
0.800	0.388	0.396	0.403	0.410	0.417	0.425	0.432	0.439	0.447	0.454
0.900	0.462	0.469	0.477	0.485	0.492	0.500	0.508	0.515	0.523	0.531

TABLE 17 DISCHARGE FOR A 6 INCH PARSHALL FLUME

FORMULA $Q = A H_a^{1.495}$

H_a - Measured head/feet

Q - Discharge/cfs

MIGD = .539 X cfs

Head (ft.)	0.00	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09
0.100	0.034	0.040	0.045	0.051	0.057	0.063	0.070	0.076	0.083	0.090
0.200	0.097	0.105	0.112	0.120	0.128	0.136	0.144	0.152	0.161	0.169
0.300	0.178	0.187	0.196	0.205	0.215	0.224	0.234	0.244	0.254	0.264
0.400	0.274	0.284	0.295	0.305	0.316	0.327	0.338	0.349	0.360	0.371
0.500	0.382	0.394	0.406	0.417	0.429	0.441	0.453	0.465	0.477	0.490
0.600	0.502	0.515	0.528	0.540	0.553	0.566	0.579	0.592	0.606	0.619
0.700	0.632	0.646	0.660	0.673	0.687	0.701	0.715	0.729	0.744	0.758
0.800	0.772	0.787	0.801	0.816	0.831	0.845	0.860	0.875	0.890	0.906
0.900	0.921	0.936	0.952	0.967	0.983	0.998	1.014	1.030	1.046	1.062
1.000	1.078	1.094	1.110	1.127	1.143	1.160	1.176	1.193	1.209	1.226
1.100	1.243	1.260	1.277	1.294	1.311	1.329	1.346	1.363	1.381	1.398
1.200	1.416	1.433	1.451	1.469	1.487	1.505	1.523	1.541	1.559	1.577

TABLE 18 DISCHARGE FOR A 9 INCH PARSHALL FLUME

FORMULA $Q = 3 H_a^{1.511}$

H_a - Measured head/feet

Q - Discharge/cfs

MIGD = .539 X cfs

Head (ft.)	0.00	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09
0.100	0.050	0.058	0.066	0.074	0.083	0.092	0.101	0.111	0.121	0.131
0.200	0.142	0.153	0.164	0.176	0.187	0.199	0.211	0.224	0.236	0.249
0.300	0.262	0.276	0.289	0.303	0.317	0.331	0.345	0.360	0.375	0.390
0.400	0.405	0.420	0.436	0.452	0.468	0.484	0.500	0.517	0.533	0.550
0.500	0.567	0.585	0.602	0.620	0.637	0.655	0.673	0.692	0.710	0.729
0.600	0.747	0.766	0.785	0.804	0.824	0.843	0.863	0.883	0.903	0.923
0.700	0.943	0.964	0.984	1.005	1.026	1.047	1.068	1.089	1.111	1.132
0.800	1.154	1.176	1.198	1.220	1.242	1.265	1.287	1.310	1.333	1.356
0.900	1.379	1.402	1.426	1.449	1.473	1.496	1.520	1.544	1.568	1.593
1.000	1.617	1.641	1.666	1.691	1.716	1.741	1.766	1.791	1.816	1.842
1.100	1.867	1.893	1.919	1.945	1.971	1.997	2.024	2.050	2.076	2.103
1.200	2.130	2.157	2.184	2.211	2.238	2.265	2.293	2.320	2.348	2.376
1.300	2.404	2.432	2.460	2.488	2.516	2.545	2.573	2.602	2.631	2.660
1.400	2.688	2.718	2.747	2.776	2.805	2.835	2.864	2.894	2.924	2.954

TABLE 19 DISCHARGE FOR A 1.0 FOOT PARSHALL FLUME

FORMULA $Q = 4 H_a^{1.522}$

H_a - Measured head/feet

Q - Discharge/cfs

MIGD = .539 X cfs

Head (ft.)	0.00	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09
0.200	0.186	0.200	0.215	0.230	0.246	0.261	0.277	0.294	0.311	0.328
0.300	0.345	0.363	0.381	0.399	0.417	0.436	0.455	0.475	0.494	0.514
0.400	0.535	0.555	0.576	0.597	0.618	0.639	0.661	0.683	0.706	0.728
0.500	0.751	0.774	0.797	0.820	0.844	0.868	0.892	0.916	0.941	0.966
0.600	0.991	1.016	1.042	1.067	1.093	1.119	1.145	1.172	1.199	1.226
0.700	1.253	1.280	1.308	1.335	1.363	1.392	1.420	1.448	1.477	1.506
0.800	1.535	1.564	1.594	1.624	1.653	1.684	1.714	1.744	1.775	1.806
0.900	1.837	1.868	1.899	1.931	1.962	1.994	2.026	2.058	2.091	2.123
1.000	2.156	2.189	2.222	2.255	2.289	2.322	2.356	2.390	2.424	2.458
1.100	2.493	2.527	2.562	2.597	2.632	2.667	2.702	2.738	2.774	2.810
1.200	2.846	2.882	2.918	2.955	2.991	3.028	3.065	3.102	3.139	3.177
1.300	3.214	3.252	3.290	3.328	3.366	3.404	3.443	3.481	3.520	3.559

cont'd.....

TABLE 19 (cont'd)

Head (ft.)	0.00	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09
1.400	3.598	3.637	3.676	3.716	3.756	3.795	3.835	3.875	3.915	3.956
1.500	3.996	4.037	4.078	4.119	4.160	4.201	4.242	4.284	4.325	4.367
1.600	4.409	4.451	4.493	4.535	4.578	4.620	4.663	4.706	4.749	4.792
1.700	4.835	4.878	4.922	4.965	5.009	5.053	5.097	5.141	5.185	5.230
1.800	5.274	5.319	5.364	5.409	5.454	5.499	5.544	5.590	5.635	5.681
1.900	5.727	5.773	5.819	5.865	5.911	5.958	6.004	6.051	6.098	6.145

TABLE 20 DISCHARGE FOR A 1.5 FOOT PARSHALL FLUME

FORMULA $Q = 6 H_a^{1.538}$

H_a - Measured head/feet

Q - Discharge/cfs

MIGD = .539 cfs

Head (ft.)	0.00	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09
0.200	0.272	0.293	0.315	0.337	0.360	0.384	0.407	0.432	0.457	0.482
0.300	0.508	0.534	0.561	0.588	0.615	0.643	0.672	0.701	0.730	0.760
0.400	0.790	0.821	0.852	0.883	0.915	0.947	0.980	1.013	1.046	1.080
0.500	1.114	1.148	1.183	1.218	1.254	1.289	1.326	1.362	1.399	1.437
0.600	1.474	1.512	1.550	1.589	1.628	1.667	1.707	1.747	1.787	1.828
0.700	1.869	1.910	1.951	1.993	2.035	2.078	2.120	2.164	2.207	2.251
0.800	2.295	2.339	2.383	2.428	2.473	2.519	2.564	2.610	2.657	2.703
0.900	2.750	2.797	2.845	2.892	2.940	2.989	3.037	3.086	3.135	3.184
1.000	3.234	3.284	3.334	3.384	3.435	3.486	3.537	3.589	3.640	3.692
1.100	3.745	3.797	3.850	3.903	3.956	4.010	4.063	4.117	4.172	4.226
1.200	4.281	4.336	4.391	4.446	4.502	4.558	4.614	4.671	4.727	4.784
1.300	4.842	4.899	4.957	5.014	5.073	5.131	5.189	5.248	5.307	5.367

cont'd.....

TABLE 20 (cont'd)

Head (ft.)	0.00	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09
1.400	5.426	5.486	5.546	5.606	5.666	5.727	5.788	5.849	5.910	5.972
1.500	6.033	6.095	6.158	6.220	6.283	6.346	6.409	6.472	6.535	6.599
1.600	6.663	6.727	6.792	6.856	6.921	6.986	7.051	7.117	7.182	7.248
1.700	7.314	7.381	7.447	7.514	7.581	7.648	7.715	7.783	7.850	7.918
1.800	7.986	8.055	8.123	8.192	8.261	8.330	8.399	8.469	8.539	8.609
1.900	8.679	8.749	8.820	8.891	8.961	9.033	9.104	9.175	9.247	9.319

TABLE 21 DISCHARGE FOR A 2 FOOT PARSHALL FLUME

FORMULA $Q = 8\ H_a^{1.550}$

H_a - Measured head/feet

Q - Discharge/cfs

MIGD = .539 X cfs

Head (ft.)	0.00	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09
0.200	0.356	0.384	0.413	0.442	0.472	0.503	0.534	0.567	0.599	0.632
0.300	0.667	0.702	0.737	0.773	0.810	0.847	0.885	0.923	0.962	1.002
0.400	1.042	1.083	1.124	1.166	1.208	1.251	1.294	1.338	1.382	1.427
0.500	1.473	1.518	1.565	1.612	1.659	1.707	1.755	1.804	1.853	1.903
0.600	1.953	2.004	2.055	2.107	2.159	2.212	2.264	2.318	2.372	2.426
0.700	2.481	2.536	2.591	2.647	2.704	2.761	2.818	2.876	2.934	2.992
0.800	3.051	3.111	3.170	3.230	3.291	3.352	3.413	3.475	3.537	3.599
0.900	3.662	3.726	3.789	3.853	3.918	3.982	4.048	4.113	4.179	4.245
1.000	4.312	4.379	4.446	4.514	4.582	4.651	4.720	4.789	4.858	4.928
1.100	4.998	5.069	5.140	5.211	5.283	5.355	5.427	5.500	5.573	5.646
1.200	5.720	5.794	5.869	5.943	6.018	6.094	6.170	6.246	6.322	6.399
1.300	6.476	6.553	6.631	6.709	6.787	6.866	6.945	7.024	7.104	7.184

cont'd.....

TABLE 21 (cont'd)

Head (ft.)	0.00	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09
1.400	7.264	7.345	7.425	7.507	7.588	7.670	7.752	7.835	7.917	8.001
1.500	8.084	8.168	8.252	8.336	8.420	8.505	8.591	8.676	8.762	8.848
1.600	8.934	9.021	9.108	9.195	9.283	9.371	9.459	9.547	9.636	9.725
1.700	9.815	9.904	9.994	10.084	10.175	10.266	10.357	10.448	10.540	10.632
1.800	10.724	10.816	10.909	11.002	11.095	11.189	11.283	11.377	11.472	11.566
1.900	11.661	11.757	11.852	11.948	12.044	12.140	12.237	12.334	12.431	12.529
2.000	12.626	12.724	12.823	12.921	13.020	13.119	13.218	13.318	13.418	13.518
2.100	13.618	13.719	13.820	13.921	14.022	14.124	14.226	14.328	14.431	14.533
2.200	14.636	14.740	14.843	14.947	15.051	15.155	15.260	15.365	15.470	15.575
2.300	15.680	15.786	15.892	15.999	16.105	16.212	16.319	16.426	16.534	16.642
2.400	16.750	16.858	16.967	17.075	17.184	17.294	17.403	17.513	17.623	17.733

TABLE 22 DISCHARGE FOR A 3 FOOT PARSHALL FLUME

FORMULA $Q = 12\ H_a^{1.566}$

H_a - Measured head/feet

Q - Discharge/cfs

MIGD = .539 X cfs

Head (ft.)	0.00	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09
0.200	0.520	0.562	0.604	0.647	0.692	0.738	0.785	0.832	0.881	0.931
0.300	0.982	1.033	1.086	1.140	1.194	1.250	1.306	1.363	1.421	1.480
0.400	1.540	1.601	1.663	1.725	1.788	1.852	1.917	1.983	2.049	2.116
0.500	2.185	2.253	2.323	2.393	2.464	2.536	2.609	2.682	2.756	2.831
0.600	2.906	2.983	3.060	3.137	3.215	3.295	3.374	3.455	3.536	3.617
0.700	3.700	3.783	3.867	3.951	4.036	4.122	4.208	4.296	4.383	4.472
0.800	4.560	4.650	4.740	4.831	4.923	5.015	5.107	5.201	5.295	5.389
0.900	5.484	5.580	5.676	5.773	5.871	5.969	6.067	6.167	6.267	6.367
1.000	6.468	6.570	6.672	6.774	6.878	6.982	7.086	7.191	7.296	7.403
1.100	7.509	7.616	7.724	7.832	7.941	8.050	8.160	8.271	8.382	8.493
1.200	8.605	8.718	8.831	8.945	9.059	9.173	9.289	9.404	9.521	9.637
1.300	9.755	9.872	9.991	10.109	10.229	10.348	10.469	10.589	10.711	10.833

cont'd.....

TABLE 22 (cont'd)

Head (ft.)	0.00	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09
1.400	10.955	11.078	11.201	11.325	11.449	11.574	11.699	11.825	11.951	12.078
1.500	12.205	12.332	12.461	12.589	12.718	12.848	12.978	13.108	13.239	13.371
1.600	13.503	13.635	13.768	13.901	14.035	14.169	14.304	14.439	14.575	14.711
1.700	14.847	14.984	15.122	15.260	15.398	15.537	15.676	15.816	15.956	16.097
1.800	16.238	16.379	16.521	16.664	16.806	16.950	17.093	17.237	17.382	17.527
1.900	17.673	17.818	17.965	18.111	18.259	18.406	18.554	18.703	18.852	19.001
2.000	19.151	19.301	19.451	19.602	19.754	19.906	20.058	20.211	20.364	20.517
2.100	20.671	20.826	20.980	21.135	21.291	21.447	21.604	21.760	21.918	22.075
2.200	22.233	22.392	22.551	22.710	22.870	23.030	23.190	23.351	23.512	23.674
2.300	23.836	23.999	24.162	24.325	24.488	24.653	24.817	24.982	25.147	25.313
2.400	25.479	25.645	25.812	25.979	26.147	26.315	26.483	26.652	26.821	26.991

TABLE 23 DISCHARGE FOR A 4 FOOT PARSHALL FLUME

FORMULA $Q = 16\ H_a^{1.578}$

H_a - Measured head/feet

Q - Discharge/cfs

MIGD = .539 X cfs

Head (ft.)	0.00	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09
0.200	0.680	0.735	0.791	0.848	0.907	0.968	1.029	1.092	1.157	1.223
0.300	1.290	1.359	1.428	1.499	1.572	1.645	1.720	1.796	1.873	1.952
0.400	2.031	2.112	2.194	2.277	2.361	2.446	2.532	2.620	2.708	2.798
0.500	2.889	2.980	3.073	3.167	3.262	3.357	3.454	3.552	3.651	3.751
0.600	3.852	3.953	4.056	4.160	4.264	4.370	4.477	4.584	4.693	4.802
0.700	4.912	5.023	5.135	5.248	5.362	5.477	5.593	5.709	5.827	5.945
0.800	6.064	6.184	6.305	6.427	6.550	6.673	6.797	6.923	7.049	7.175
0.900	7.303	7.431	7.561	7.691	7.822	7.953	8.086	8.219	8.353	8.488
1.000	8.624	8.760	8.898	9.036	9.175	9.314	9.455	9.596	9.738	9.880
1.100	10.024	10.168	10.313	10.458	10.605	10.752	10.900	11.049	11.198	11.348
1.200	11.499	11.650	11.803	11.956	12.110	12.264	12.419	12.575	12.732	12.889
1.300	13.047	13.206	13.365	13.525	13.686	13.848	14.010	14.173	14.336	14.501

cont'd.....

TABLE 23 DISCHARGE FOR A 4 FOOT PARSHALL FLUME

FORMULA $Q = 16\ H_a^{1.578}$

H_a - Measured head/feet

Q - Discharge/cfs

MIGD = .539 X cfs

Head (ft.)	0.00	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09
0.200	0.680	0.735	0.791	0.848	0.907	0.968	1.029	1.092	1.157	1.223
0.300	1.290	1.359	1.428	1.499	1.572	1.645	1.720	1.796	1.873	1.952
0.400	2.031	2.112	2.194	2.277	2.361	2.446	2.532	2.620	2.709	2.798
0.500	2.889	2.980	3.073	3.167	3.262	3.357	3.454	3.552	3.651	3.751
0.600	3.852	3.953	4.056	4.160	4.264	4.370	4.477	4.584	4.693	4.802
0.700	4.912	5.023	5.135	5.248	5.362	5.477	5.593	5.709	5.827	5.945
0.800	6.064	6.184	6.305	6.427	6.550	6.673	6.797	6.923	7.049	7.175
0.900	7.303	7.431	7.561	7.691	7.822	7.953	8.086	8.219	8.353	8.488
1.000	8.624	8.760	8.898	9.036	9.175	9.314	9.455	9.596	9.738	9.880
1.100	10.024	10.168	10.313	10.458	10.605	10.752	10.900	11.049	11.198	11.348
1.200	11.499	11.650	11.803	11.956	12.110	12.264	12.419	12.575	12.732	12.890
1.300	13.047	13.206	13.365	13.525	13.686	13.848	14.010	14.173	14.336	14.501

cont'd.....

TABLE 23 (cont'd)

Head (ft.)	0.00	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09
1.400	14.666	14.831	14.998	15.165	15.332	15.501	15.670	15.839	16.010	16.181
1.500	16.352	16.525	16.698	16.871	17.046	17.221	17.396	17.573	17.750	17.927
1.600	18.105	18.284	18.464	18.644	18.825	19.006	19.188	19.371	19.555	19.738
1.700	19.923	20.108	20.294	20.481	20.668	20.856	21.044	21.233	21.423	21.613
1.800	21.804	21.995	22.187	22.380	22.573	22.767	22.961	23.157	23.352	23.549
1.900	23.746	23.943	24.141	24.340	24.539	24.739	24.940	25.141	25.342	25.545
2.000	25.747	25.951	26.155	26.360	26.565	26.770	26.977	27.184	27.391	27.599
2.100	27.808	28.017	28.227	28.438	28.648	28.860	29.072	29.285	29.498	29.712
2.200	29.926	30.141	30.357	30.573	30.789	31.007	31.224	31.443	31.661	31.881
2.300	32.101	32.321	32.542	32.764	32.986	33.209	33.432	33.656	33.880	34.105
2.400	34.331	34.557	34.783	35.010	35.238	35.466	35.695	35.924	36.154	36.384

TABLE 24 DISCHARGE FOR A 5 FOOT PARSHALL FLUME

FORMULA $Q = 20\ H_a^{1.587}$

H_a - Measured head/feet

Q - Discharge/cfs

MIGD = .539 X cfs

Head (ft.)	0.00	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09
0.200	0.838	0.906	0.975	1.046	1.119	1.194	1.271	1.350	1.430	1.512
0.300	1.595	1.680	1.767	1.856	1.946	2.037	2.130	2.225	2.321	2.419
0.400	2.518	2.619	2.721	2.824	2.929	3.036	3.144	3.253	3.363	3.475
0.500	3.588	3.703	3.819	3.936	4.054	4.174	4.295	4.418	4.541	4.666
0.600	4.792	4.920	5.048	5.178	5.309	5.441	5.575	5.710	5.845	5.982
0.700	6.121	6.260	6.400	6.542	6.685	6.829	6.974	7.120	7.267	7.416
0.800	7.565	7.716	7.868	8.020	8.174	8.329	8.485	8.642	8.801	8.960
0.900	9.120	9.281	9.444	9.607	9.772	9.937	10.104	10.271	10.440	10.609
1.000	10.780	10.952	11.124	11.298	11.472	11.648	11.824	12.002	12.180	12.360
1.100	12.540	12.722	12.904	13.087	13.272	13.457	13.643	13.830	14.018	14.207
1.200	14.397	14.588	14.780	14.973	15.166	15.361	15.556	15.753	15.950	16.148
1.300	16.347	16.547	16.748	16.950	17.153	17.356	17.561	17.766	17.972	18.180

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